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THE PURPOSES OF THIS OFF-POST INTERIM RESPONSE ACTION ALTERNATIVES ASSESSMENT ARE TO:

1. SET FORTH THE IRA OBJECTIVES
2. SUMMARIZE THE EVALUATIONS PERFORMED AND THE ESTIMATED COSTS FOR T ALTERNATIVES CONSIDERED
3. PRESENT A CONCEPTUALIZATION OF THE PREFERRED ALTERNATIVE.

SECTIONS OF THIS REPORT INCLUDE:

1. INFORMATION ON THE IRA PROCESS
2. STUDY AREA DESCRIPTION INCLUDING CONTAMINANTS OF CONCERN
3. INTERIM RESPONSE ACTION OBJECTIVES
4. GENERAL RESPONSE ACTIONS - ALTERNATIVE WATER SUPPLY, MANAGEMENT O CONTAMINANT MIGRATION, AND GROUND WATER TREATMENT
5. TECHNOLOGY INVENTORY OF POTENTIALLY APPLICABLE PROCESSES
6. DEVELOPMENT OF A PREFERRED ALTERNATIVE INCLUDING COSTS.

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OFFPOST INTERIM RESPONSE ACTION ALTERNATIVES ASSESSMENT DRAFT FINAL REPORT

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Harding Lawson Associates

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SHOULD BE REFERRED TO PROGRAM MANAGER
FOR ROCKY MOUNTAIN ARSENAL CLEANUP, AMXRM-PM,
ABERDEEN PROVING GROUND, MARYLAND 21010

TECHNICAL SUPPORT FOR ROCKY MOUNTAIN ARSENAL

Offpost Interim Response Action
Alternatives Assessment
Draft Final Report
(Version 2.3)

December 1988
Contract Number DAAA15-88-D-0021
RI/FS-1

PREPARED BY

HARDING LAWSON ASSOCIATES

PREPARED FOR

OFFICE OF THE PROGRAM MANAGER
ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

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1.0 INTRODUCTION

This document presents the results of an Interim Response Action (IRA) alternatives assessment for the Offpost Operable Unit of Rocky Mountain Arsenal (RMA). The need for this alternatives assessment for the offpost area was previously identified by the U.S. Army (Army) as described in the Technical Program Plan (TPP) (Ebasco and others, 1987) and Section IX of the proposed Consent Decree. The purpose of the assessment is to evaluate appropriate remedial alternatives and to select the most efficient and cost-effective alternative for attaining the objectives of the IRA.

Previous investigations, including the Draft Water Remedial Investigation (RI) Report (ESE, 1988a) and the Draft RI Report (ESE, 1988b), have shown that alluvial ground water is the primary pathway for offpost migration of contaminants. Additionally, the proposed Consent Decree states that the IRA for the offpost area will consist of an intercept and treatment system. Because this assessment is for an IRA, *timeliness and cost-effectiveness* are important considerations. The remedial technologies under consideration must be capable of being readily implemented and have demonstrated performance for the site conditions and contaminants of concern. As a result, only those technologies recognized as proven, which would require limited pilot testing or treatability studies, are applicable to this IRA. More extensive evaluations are considered part of the Feasibility Study (FS) currently in progress (ESE, in progress). Thus, this alternatives assessment addresses only the interim remediation of offpost alluvial ground water, and only those technologies appropriate for that purpose are considered in this document.

The purpose of this Offpost IRA Alternatives Assessment Report is to (1) set forth the IRA objectives, (2) summarize the evaluations performed and the estimated costs for the alternatives considered, and (3) present a conceptualization of the preferred IRA alternative. As such, this document does not present specific design information, such as well locations or other design-level criteria for the preferred alternative. Design-specific information will be contained in future Remedial Action/Remedial Design (RA/RD) documents.

The overall goal of the IRA for the offpost area is to initiate appropriate remedial activities in advance of the final remedy and to continue or modify, as appropriate, alternative water-supply programs that limit the potential for exposure from contaminated alluvial ground water. Based on this goal, the following have been identified as necessary components of the IRA:

- Management of contaminated alluvial ground-water migration to mitigate the spread of contaminants
- Treatment of contaminated alluvial ground water to effect reduced contaminant concentrations
- Continued reduction of potential human exposure from contaminated ground water by continuing to provide alternative water supplies to potentially exposed populations

To evaluate the appropriateness of the scope and focus of this assessment, it is necessary to fully understand the IRA process for RMA. As described more fully in Section 1.3, IRA Process, following submittal of this document, an IRA Decision Document will be prepared and submitted to the Parties and State (PAS) for their review and comment. Following review and approval of the Decision Document, an IRA Implementation Document will be submitted to the PAS.

The remaining portions of this section of the report present more detailed discussion of the purpose and objectives of the IRA, including a description of the site history, a brief discussion of the IRA study area, and a discussion of the IRA process. Subsequent sections of this document are organized as follows:

2.0 Study Area Description

3.0 Interim Response Action Objectives

4.0 General Response Actions

5.0 Technology Inventory and Screening

6.0 Alternatives Development and Screening

1.1 BACKGROUND

RMA is located northeast of Denver in Adams County, Colorado, as shown in Figure 1-1. RMA was established in 1942 as a facility for the manufacture of chemical munitions. From the 1940s to the early 1980s, the site was used for chemical manufacturing and demilitarization of munitions. Industrial and waste disposal practices of both the Army and lessees during that time have resulted in soil, surface-water and ground-water contamination both onpost and offpost. As a result, the RMA site was added to the National Priorities List (NPL) in 1984 and is subject to compliance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Investigations were initiated at RMA to identify potential areas of onpost soil contamination, probable contaminant migration pathways, and areas of ground-water contamination. Based on the results of these investigations, three onpost ground-water interception, treatment, and recharge systems were designed and installed to prevent the migration of contaminated ground water to offpost areas. These systems inhibit the migration of RMA contaminants along the northern, northwestern, and western boundaries of RMA and treat and together recharge approximately one billion gallons of ground water annually.

1.2 IRA STUDY AREA

The IRA study area extends from the northern boundary of RMA to O'Brian Canal, as shown on Figure 1-2. This area encompasses approximately four square miles. First Creek is an ephemeral stream that flows across RMA and the IRA study area to O'Brian Canal. There are no other major surface-water courses within the study area.

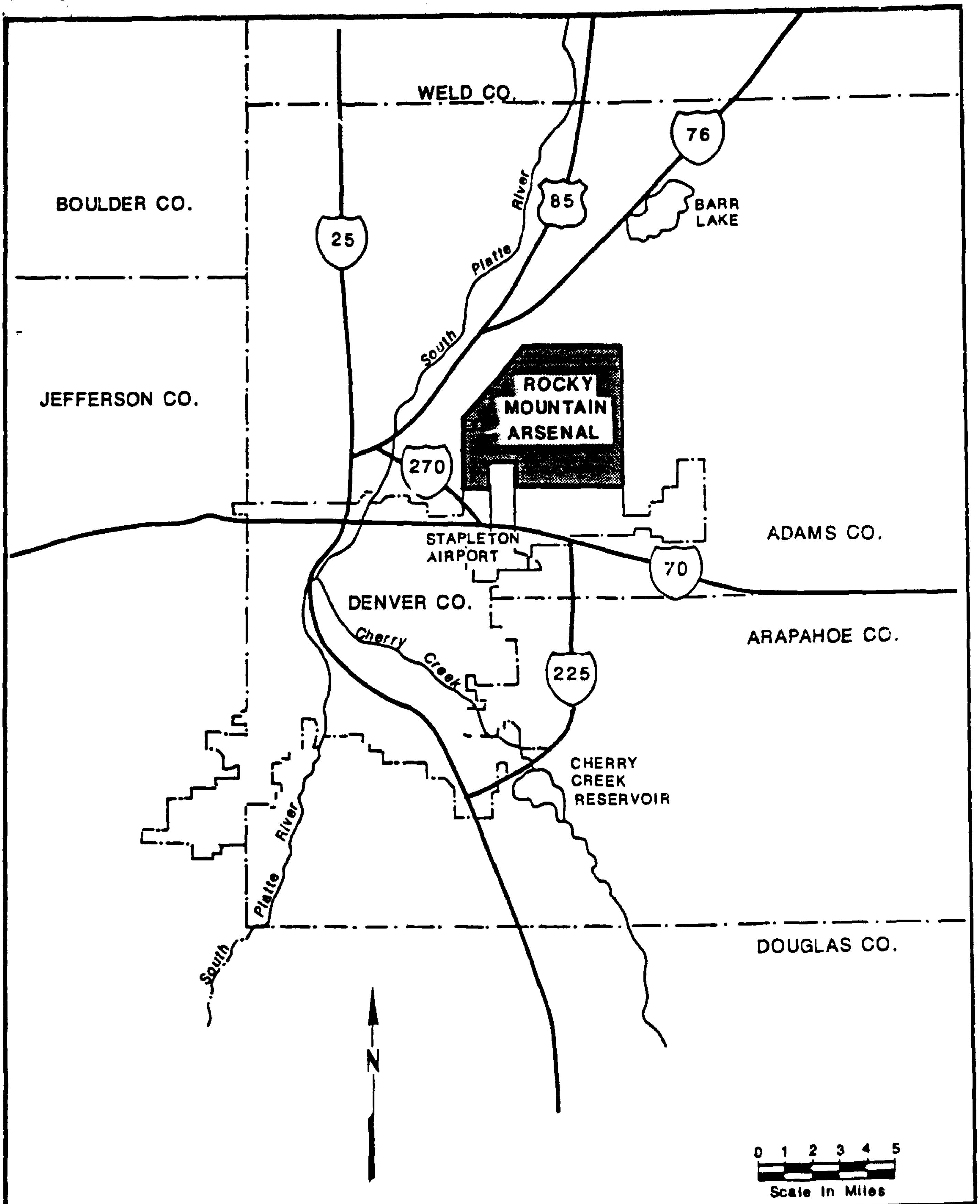

Figure 1-1
LOCATION MAP OF
ROCKY MOUNTAIN ARSENAL

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

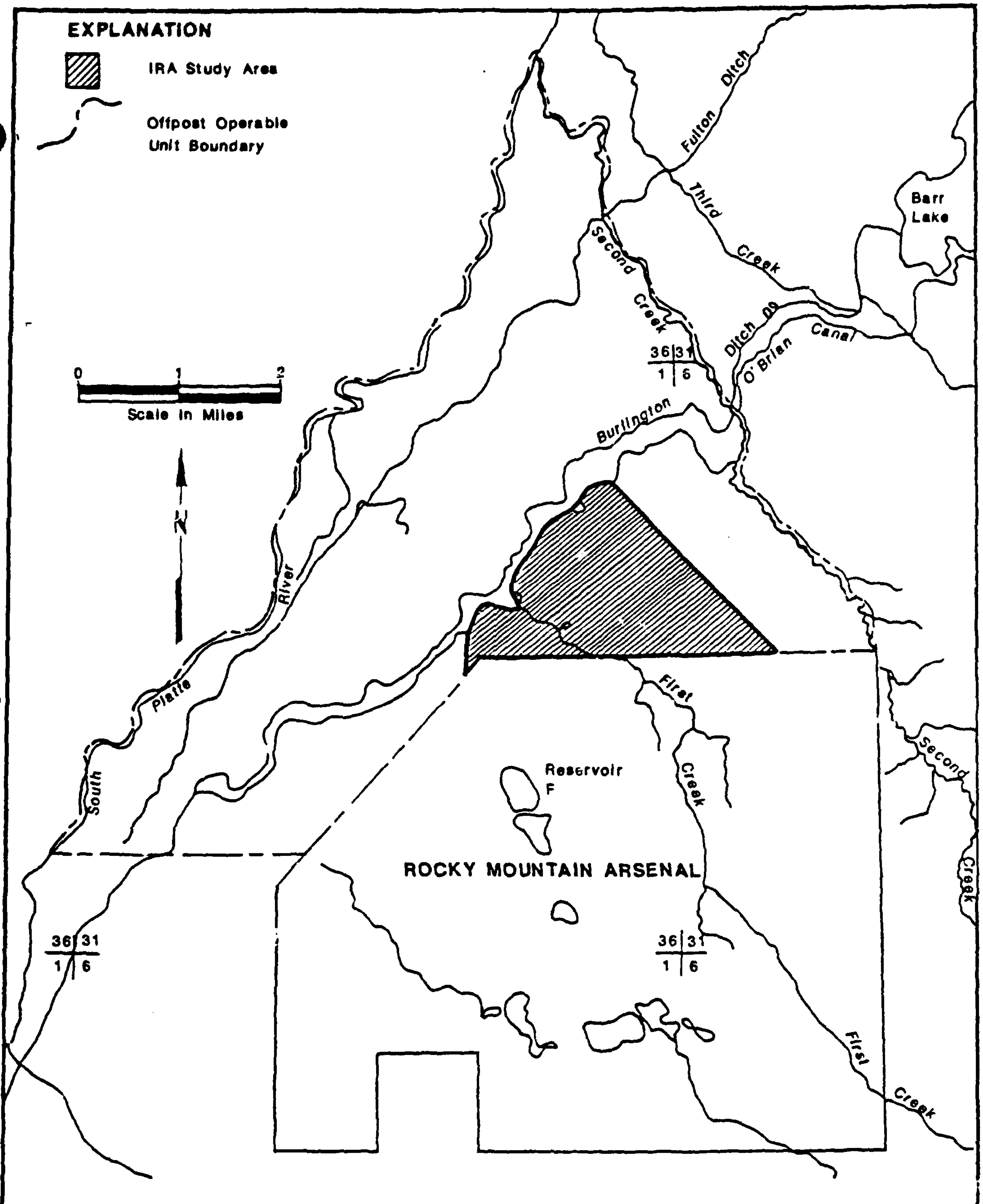

Figure 1-2
STUDY AREA FOR THE INTERIM RESPONSE ACTION ALTERNATIVES ASSESSMENT

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U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

The delineation of this offpost area as the IRA study area is principally based on (1) conclusions contained in the Draft Water RI Report (ESE, 1988a) regarding offpost migration of contaminants and (2) the interim response objectives of the IRA (Section 3.0). The specific findings of the draft RI with respect to the offpost IRA study area include:

- The First Creek and Northern Paleochannels are the primary pathways for offpost migration of contaminants across the northern RMA boundary.
- The highest concentrations of contaminants in the offpost alluvial ground water occur along these two pathways upgradient of Burlington Ditch and O'Brian Canal.
- The greatest flux of contaminants to downgradient areas generally occurs along the axes of the paleochannels, where the saturated thickness of the alluvium is greatest and the contaminant concentrations are highest.

Based on these findings and the IRA objective of initiating ground-water remediation to mitigate further downgradient migration of contaminated ground water, the IRA study area has been established to include both northern offpost contaminant plumes.

1.3 IRA PROCESS

The IRA element of the RMA environmental program consists of selected interim response actions to be initiated prior to the decision selecting the final remedy. The Army, in cooperation with the PAS, has identified 13 specific IRAs for the Onpost and Offpost Operable Units (OUs) that are considered necessary and appropriate to commence in advance of issuance of the Record of Decision (ROD). These IRAs are "removal" actions as provided in CERCLA Section 101(23), 42 U.S.C. Section 9601(23), and will be carried out in accordance with CERCLA Section 104, 42 U.S.C. Section 9604. (See also 40 CFR Sections 300.6 and 300.65.) The IRAs will be designed and implemented to be consistent with and contribute to the efficient performance of the Final Response Actions for the Onpost and Offpost OUs to the maximum extent practicable. The IRAs are to be governed by the process set forth in Section

IX of the proposed Consent Decree. The schedule for completing the offpost IRA is contained in the TPP.

The basic IRA process is shown in the diagram in Figure 1-3. The goal of the IRA Alternatives Assessment is the evaluation of appropriate alternatives and the selection of the most efficient and cost-effective alternative for attaining the objective of the IRA. The evaluation of alternatives may be based on, but will not be limited to (1) such factors as protection of human health and the environment, (2) mitigation of potential threats to human health and the environment, (3) technical feasibility, (4) institutional consideration, and (5) reasonableness of cost and timeliness. Additionally, IRAs will, to the maximum extent practicable, attain potential ARARs as described below.

Following the issuance of the Final IRA Alternatives Assessment Report, the Army will issue a proposed IRA Decision Document. The proposed IRA Decision Document will be a concise document that (1) states the objective of the IRA, (2) discusses alternatives, if any, that were considered, (3) provides the rationale for the alternative selected, (4) presents the Army's final ARAR decision, (5) summarizes the significant comments received regarding the IRA and the Army's responses to comments, and (6) establishes the IRA deadline for completion of the IRA, if appropriate.

As mentioned previously, IRAs are to be consistent with and contribute to the efficient performance of the Final Response Actions for the Onpost and Offpost OUs. Additionally, if an IRA will not fully address the threat posed by a release and a further response is required, an orderly transition will be ensured from the IRA to the Final Response Actions. To ensure the accomplishment of these requirements, it is essential to provide for the maximum exchange of information between the RI/EA/FS and the IRA.

The interaction between IRAs and the FS process is important. If an IRA is identified, planned, and executed, the FS alternatives analysis will take into account the IRA. If,

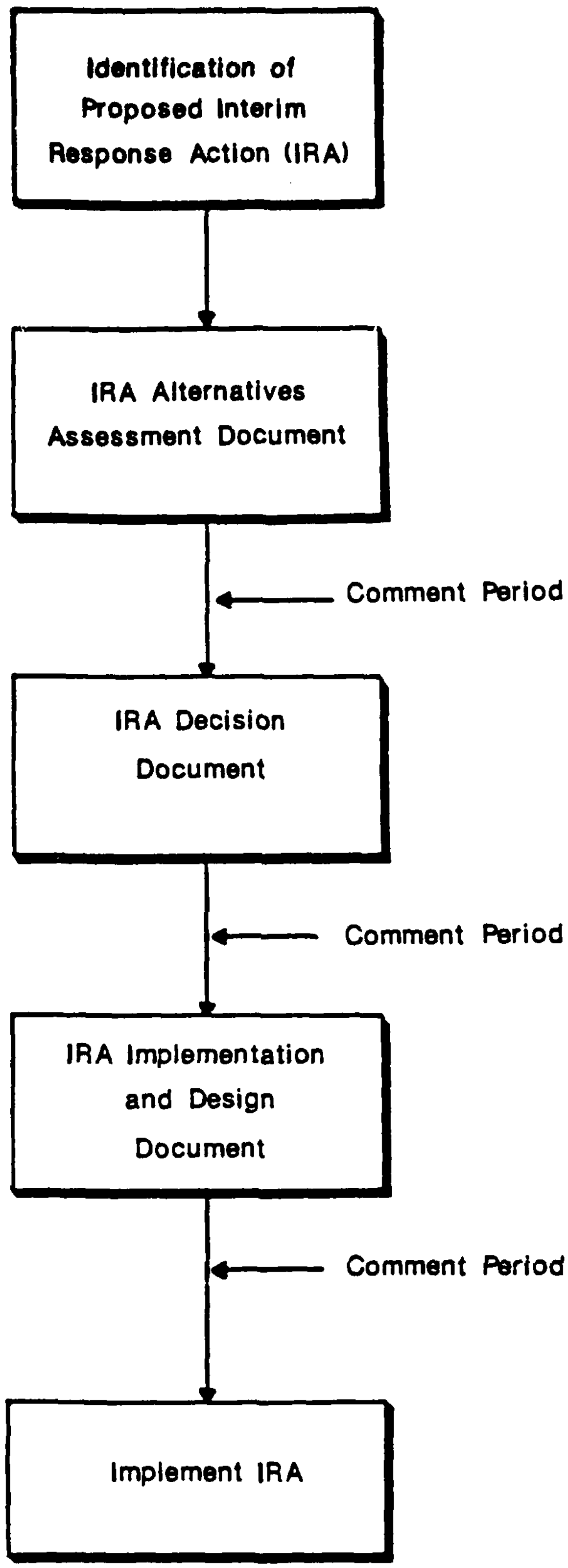


Figure 1-3
INTERIM RESPONSE ACTION PROCESS

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

however, the IRA is not executed by the time the FS is ready to propose a final response action, such proposed final response action will consider the IRA but will not be driven by the IRA. In any event, an IRA will be consistent with the proposed final response action.

The Army will take steps to ensure that IRAs make maximum use of existing RI and EA data and that the FS program element is apprised of the status of the IRAs and any data generated that may be of use to the FS. Although the IRAs have separate assessment activities that may parallel RI/EA/FS efforts, every effort will be made to avoid duplication of work between Interim and Final Response Action activities.

1.3.1 Proposed Applicable or Relevant and Appropriate Requirements (ARARs) for Offpost IRA

The interim action process reported in the June 5, 1988, matter of United States v. Shell Oil Co. provides that the IRAs, including this offpost IRA, shall, to the maximum extent practicable, attain potential ARARs. A similar provision appears in Paragraph 9.7 of the proposed Consent Decree.

Potential chemical-specific ARARs have been identified for the Offpost OU in support of the EA and FS. Potential ARARs were identified for all target analytes historically detected in the Offpost OU. These potential ARARs are listed in Appendix A and will constitute the cleanup goals for the IRA. For chemicals for which ARARs do not exist, the analytical detection limits will be used as an interim cleanup goal. However, because the offpost IRA is by definition an "interim" action, it may not be possible to attain these levels of cleanup. The time required to achieve ARARs may greatly exceed the anticipated life of the IRA. Additionally, it may be necessary to conduct long-term treatability studies or pilot tests to document a treatment technology that would be capable of eventually attaining ARARs. These situations are clearly beyond the scope of the offpost IRA and may limit the ability of the IRA to attain ARARs. If ARARs are not attained within the duration of the IRA, the Final Response Action will be required to address potential threats to public health and environment posed by the contaminants in the offpost area.

2.0 STUDY AREA DESCRIPTION

2.1 HYDROGEOLOGY

2.1.1 Geology

RMA is located on the northern flank of the Denver Basin, an elongated north-south trending asymmetric syncline approximately 300 miles long and 200 miles wide. Denver Basin formations relevant to the study area are the Arapahoe Formation (older) and the Denver Formation (younger). The primary focus of studies to date has been the unconsolidated Quaternary surficial deposits, known collectively as "alluvium," and the Denver Formation, which is the shallowest bedrock formation within the study area. There has been no evidence of Arapahoe Formation contamination associated with RMA; therefore, the Arapahoe Formation is not considered further.

Alluvium

Unconsolidated alluvial and eolian sediments cover most of the IRA study area. During Quaternary time, the surface of the Denver Formation was severely eroded by paleostreams tributary to the ancestral South Platte River. The stratigraphic thickness of the Denver Formation was progressively reduced toward the northwest, and paleochannels were incised into the bedrock surface. Over time, these channels were filled with coarse-grained sediments. Later events such as the formation of terraces by the South Platte River and the blanketing of the area by eolian deposits further influenced the local geology.

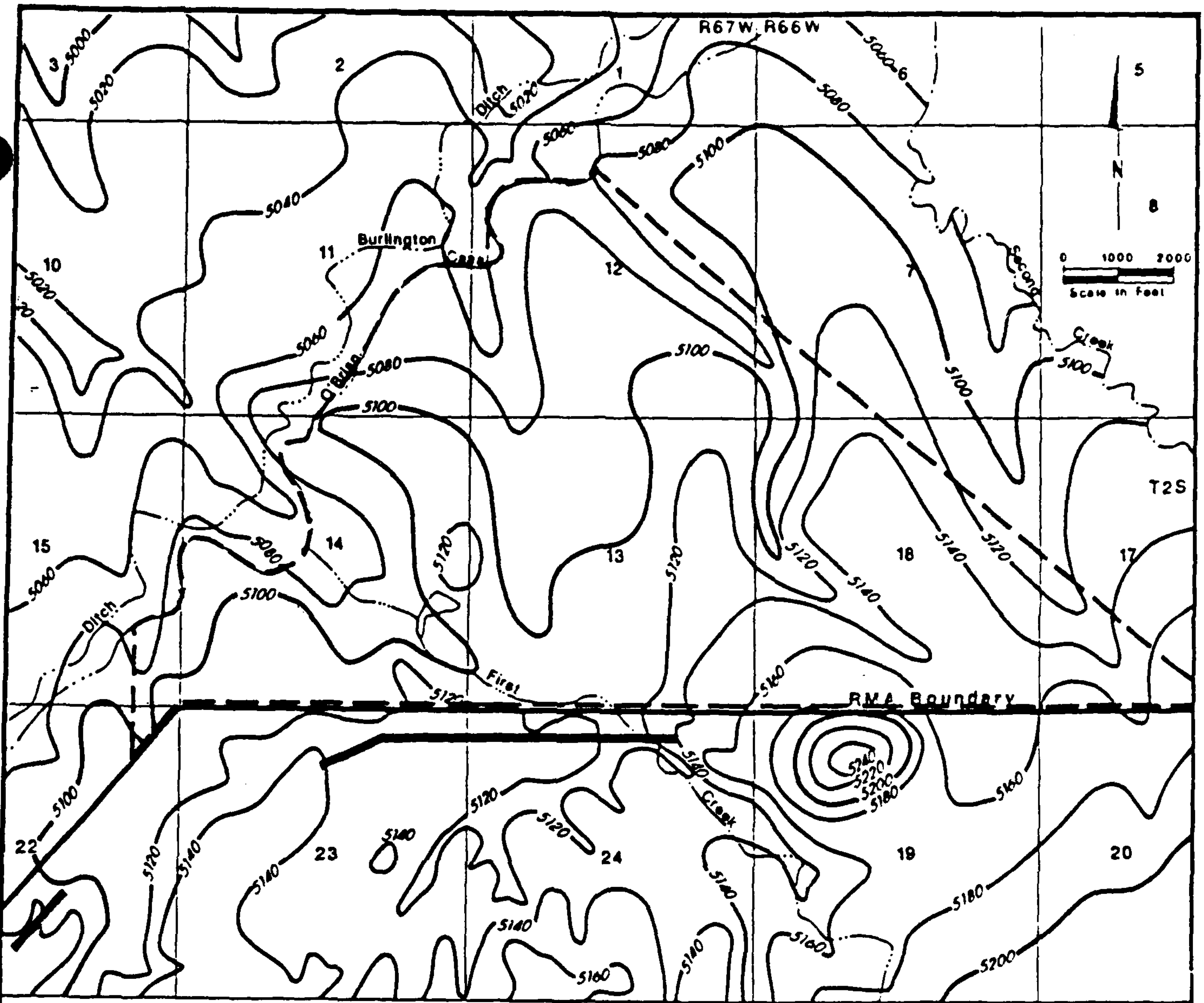
The alluvial units of concern in the study area are the Broadway Alluvium, eolian sand and loess units, and the Piney Creek Alluvium. The coarse Broadway Alluvium is from 0 to 30 feet thick and forms a low, mile-wide terrace east of the South Platte River flood plain. Overlying the Broadway Alluvium are silty loess and eolian sand deposits that blanket most of the interfluvial areas in the study area. These deposits are generally less than 20 feet thick.

The Piney Creek Alluvium is the youngest unit in the study area and was deposited by a tributary of the South Platte River. These fluvial deposits are generally less than five feet thick and are present within the study area only in the First Creek channel area.

Denver Formation

The Denver Formation immediately underlies the alluvium at depths ranging from 20 to 50 feet. This formation was deposited in low-energy environments that gave rise to claystones, siltstones, shales, lignites (coals), and sandstones. Denver Formation sandstones are commonly discontinuous, poorly cemented, lenticular (channel-like), and poorly interconnected. They are commonly silty and are generally isolated from each other by thick sequences of clay-shale and siltstone. The thin, tabular, crevasse-splay sand bodies tend to be more areally extensive but cannot be correlated over large areas. Units comprising the Denver Formation strike northeast and dip southeast at less than one degree. Hence, there is a low-angle unconformable relationship between the Denver Formation and the alluvium that results in Denver Formation units subcropping against alluvial units.

The topography of the bedrock surface (Figure 2-1) shows evidence of extensive erosion of the Denver Formation prior to alluvial deposition. This is evident in the northwestward slope of the bedrock surface and the presence of three paleochannels in the study area. The easternmost of these paleochannels in Sections 7, 12, and 18 exerts no apparent influence on contaminant migration and is therefore not of concern. The other two paleochannels, however, correspond to two preferred migration routes for contaminants leaving RMA. The Northern Paleochannel is believed to have been formed by headward (southward) erosion of the bedrock surface within a northerly draining paleostream. The Northern Paleochannel begins in southwestern Section 13 and trends north-northwest through the study area. The First Creek paleochannel enters the study area in southwestern Section 13/southeastern



EXPLANATION

Boundary Containment System

IRA Study Area Boundary

RMA Boundary

5120 Bedrock Surface Elevation
(Feet above MSL)
Contour Interval=20 feet

Figure 2-1
GENERALIZED BEDROCK SURFACE
ELEVATION CONTOUR MAP

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U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Section 14 and trends northwest through Section 14. Whether the two channels join in southwestern Section 13 has not been determined.

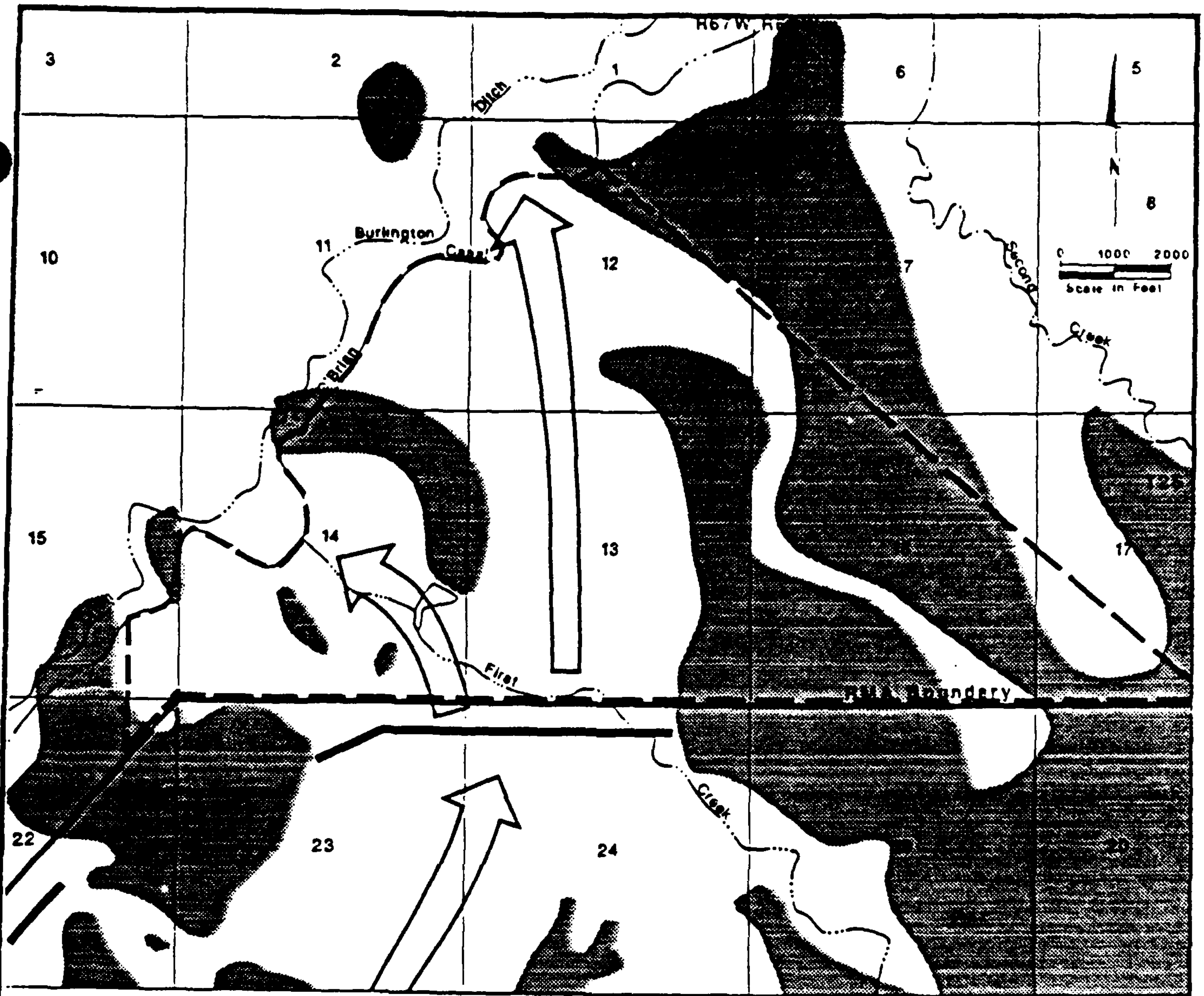
2.1.2 Hydrology

Ground water in the study area occurs in Quaternary alluvium and in water-bearing units of the Denver Formation. The Denver Formation and the overlying alluvium comprise the shallow ground-water system within which chemical contamination related to RMA has been identified. The bulk of ground-water flow and ground-water contamination is observed to occur within the alluvium.

Ground water in alluvial materials within the study area is characterized by unconfined flow conditions and a north to northwest flow direction. This is consistent with the regional flow direction toward the South Platte river, which is the regional discharge point for both ground-water and surface-water regimes.

The hydraulic gradient of the water-table surface ranges from .002 to .022 in a northwesterly direction. The water table in some areas drops below the bedrock surface, leaving the alluvium unsaturated. Such areas of unsaturated alluvium are present in eastern Section 13 and south of First Creek and north of First Creek in Section 14 (Figure 2-2). Unconfined ground-water flow in these areas occurs within the upper Denver Formation. The greatest alluvial thickness and saturated thickness occur in the vicinity of the First Creek Paleochannel and the Northern Paleochannel and decrease near subsurface bedrock highs.

The saturated zone generally includes basal sands and sandy gravels as well as overlying clays and silty clays. About 55 to 60 percent of the saturated, unconsolidated sediments are sand and gravel, and 40 to 45 percent are silt and clay. The coarser alluvial sediments are more significant because of their higher hydraulic conductivity compared to finer-grained sediments.



EXPLANATION

Boundary Containment System

RMA Boundary

IRA Study Area Boundary

Area Of Unsaturated Alluvium

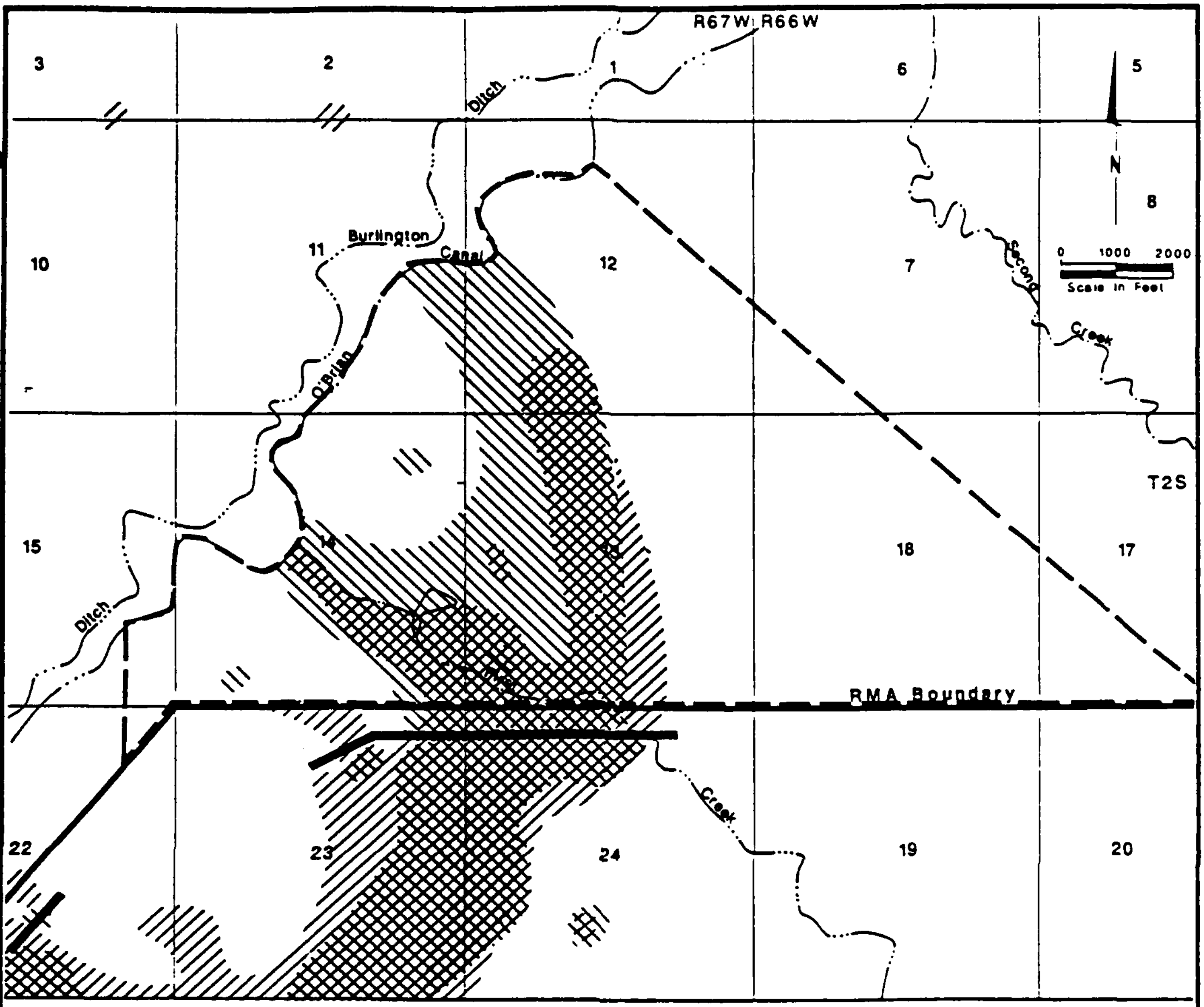
Primary Ground-Water Flow Path

Figure 2-2 UNSATURATED ALLUVIUM AND PRIMARY FLOW PATHS IN VICINITY OF IRA STUDY AREA	Prepared for: U.S. Army Program Manager's Office For Rocky Mountain Arsenal Aberdeen Proving Ground, Maryland

In the study area, the saturated region is bounded by several areas of unsaturated alluvium (Figure 2-2). These areas occur near bedrock highs, which are located along the east edge of Section 13 into Section 12, along the west edge of Section 13 and the east edge of Section 14, and south of First Creek in Section 14. In areas of unsaturated alluvium, the water table is in the upper Denver Formation. Pumping and slug test data from the alluvium and the Denver Formation indicate that hydraulic conductivities in Denver Formation aquifers are approximately two orders of magnitude lower than alluvial hydraulic conductivities. Therefore, shallow ground water flowing through the study area will tend to preferentially flow through saturated alluvium and around areas of unsaturated alluvium. Because saturated alluvial thickness and hydraulic conductivity are greater in the paleochannels, the flux of ground water flowing through these pathways is large compared to that in bedrock high areas. Ground water and associated contamination tend to follow these pathways, as confirmed by the distribution of contaminant plumes across the study area (Figure 2-3).

Alluvial/Denver Formation Interactions

The potential for vertical ground-water movement between the alluvium and the Denver Formation was assessed by evaluating the differences in water elevations between wells at cluster sites. Downward gradients were indicated at sites where there were no subcropping Denver Formation sands, whereas an upward hydraulic gradient was indicated where there was a subcropping Denver Formation sand. This is consistent with more extensive data from the RMA Draft Water RI Report (ESE, 1988a). These observations indicate that there is a potential for (1) downward ground-water movement in areas of Denver Formation aquitard subcrop and (2) upward ground-water movement in areas of Denver Formation sand subcrop. As indicated in the Draft Water RI Report, the vertical hydraulic conductivity in Denver Formation aquitards is sufficiently low as to preclude extensive, rapid, downward ground-water movement. Indications are that contamination in the upper Denver Formation is the



EXPLANATION

Boundary Containment System

RMA Boundary

IRA Study Area Boundary

Area of Volatile Organic Compounds and DBCP (Benzene, CCL4, DBCP, TCE, TCLEE)

Area of Pesticides (Aldrin, Dieldrin, Endrin)

Reference : Draft Offpost RI Report (ESE, 1988)

Figure 2-3
MAXIMUM EXTENT OF SELECTED CONTAMINANTS IN THE ALLUVIAL AQUIFER

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result of either enhanced vertical fracturing or poorly constructed wells. In areas where Denver Formation aquifers subcrop against alluvium, upward vertical flow occurs. However, because Denver Formation aquifers are not as permeable as alluvium, the flow contribution from the Denver Formation is considered small compared to the horizontal flow occurring in the alluvium.

2.1.3 Surface Water

Surface-water bodies within the study area include First Creek (Sections 13 and 14), a man-made pond located along the creek in southeast Section 14, and O'Brian Canal and Burlington Ditch along the northwest boundary of the area. Flow in First Creek enters the study area at the northern RMA boundary and flows northwest until it is intercepted by O'Brian Canal. From there, O'Brian Canal flows northeast, supplying water to several irrigation ditches downstream. When surplus water exists, the water from the canal flows downgradient and is stored in Barr Lake to the northeast. First Creek may receive flow by direct overland flow from RMA or by recharge to the channel from alluvial or Denver Formation ground water.

Natural flows in First Creek are intermittent. Flow in the stream diminishes as it crosses RMA, and the channel disappears northwest of O'Brian Canal. First Creek flows are diverted entirely by O'Brian Canal and range from a minimum of no flow to calculated maximum flows of 164 cubic feet per second (cfs) and 5350 cfs for 2-year and 100-year flood stages, respectively. Maximum flows in O'Brian Canal may reach 950 cfs, and Burlington Ditch maximum flows may reach 200 cfs. These canals are designed to accept natural flows during near normal flow periods, but they could not accept very high flows such as those projected from First Creek during 100-year flood events.

2.1.4 Ground-Water/Surface-Water Interactions

Ground-water/surface-water interactions in the vicinity of RMA have been evaluated using a water budget approach with the basic premise that inflow minus outflow equals the change in storage for a surface-water course or lake. At present, qualitative observations of the First Creek channel in the vicinity of the North Boundary Containment System (NBCS) can be used to draw some preliminary conclusions regarding the interactions between surface water and ground water. First, there appears to be significant interaction between ground water and First Creek, indicated by changes in flows at various points along the drainage course. Second, the marshy conditions near the North Bog and at the confluence of First Creek and O'Brian Canal indicate significant ground-water/surface-water interaction in these areas.

The water table near the North Bog and at the confluence of First Creek and O'Brian Canal is very near ground surface. In the area of First Creek and O'Brian Canal, this condition likely results from ground-water discharges (discussed below). In the area of the North Bog, marshy conditions result from artificial recharge of water released from the NBCS treatment system, which causes mounding of the alluvial water table.

As First Creek traverses the onpost area, it appears to be contributing a portion of its flow to ground water and thus behaves as a losing stream. The opposite behavior is apparent north of RMA, where it appears that the stream is gaining from ground water, resulting in more consistent flows in this northern segment than those observed to the south. In the area of the confluence of First Creek and O'Brian Canal, marshy conditions indicate significant ground-water/surface-water interaction.

2.2 GROUND-WATER CONTAMINATION

Chemical contamination originating at RMA has migrated to the study area principally through the alluvial ground-water system and presently exists in two main plumes (Figure 2-3). The first plume (the Northern Plume) begins in southwest Section 13 and southeast Section 14 and from there trends northward, reaching the O'Brian Canal in western Section 12. The second plume (the First Creek Plume) also begins in southern Sections 13 and 14 but trends northwestward along First Creek, reaching O'Brian Canal in central Section 13. Chemical evidence (ESE, 1988a) suggests that the plumes continue northward and northwestward past O'Brian Canal, but chemical concentrations past this feature are greatly reduced. The width of the northern plume, as defined by chemical detection limits, is approximately 2500 feet, and the width of the First Creek plume is approximately 800 feet to 4500 feet, depending on the compound under consideration. A more complete description of the extent of ground-water contamination in the offpost area is presented in the Draft Water RI Report (ESE, 1988a).

2.3 CHEMICALS PRESENT

The chemicals detected in the two plumes within the study area are as follows:

- Chlorinated pesticides - aldrin, dieldrin, endrin, isodrin, p,p'DDE, p,p'DDT
- DBCP (dibromochloropropane)
- DCPD (dicyclopentadiene)
- DIMP (diisopropylmethylphosphonate)
- Organophosphorous pesticides
- pCPMS-SO-SO_2 (pChlorophenylmethyl sulfide, sulfoxide, and sulfone)
- Dithiane - oxathiane
- Purgeable organohalogens - many chlorinated methanes, ethanes, and ethenes
- Purgeable aromatics - including aromatic hydrocarbons, benzene, toluene, xylenes, and ethyl benzene
- Arsenic
- Mercury
- Base metals - including cadmium, chromium, copper, lead, and zinc

The chemicals listed above are present in either the First Creek Plume or the Northern Plume or in both plumes. In the First Creek Plume, the apparent center of mass for most contaminants is within 500 feet of First Creek. Hence, the axis along which the highest chemical concentrations were detected corresponds approximately to the course of First Creek. The apparent center of mass of the Northern Plume for most compounds is approximately 1000 feet east of the section line in Section 13 and turns northwestward in Section 12. Within each plume, concentrations of the various chemical constituents decrease away from the axes and eventually drop below compound detection limits.

2.4 CONTAMINANTS OF CONCERN

Based on the results of the Draft Water RI Report (ESE, 1988a) and the Preliminary Draft EA/FS Report (ESE, in progress), the contaminants of concern in the Offpost OU are aldrin, benzene, DDE, chloroform, DBCP, 1,2-dichloroethane, dieldrin, and tetrachloroethylene in alluvial ground water. The identification of these chemicals as contaminants of concern is based on their generally widespread distribution, concentration range, and general toxicity.

3.0 INTERIM RESPONSE ACTION OBJECTIVES

As part of the RMA environmental program, IRAs are being implemented to provide varying levels of site remediation prior to completing the RI/EA/FS process and in advance of issuance of the ROD. The overall objective of the IRA for the offpost study area, as specified in the TPP is to "...minimize the risk of future exposure from contaminated ground-water plumes north of RMA." Although available information indicates no current exposure from contaminated ground water in the offpost area, (ESE, 1987 and 1988a), the mitigation of contaminant migration is included in the offpost IRA to reduce the potential for future exposure and to begin some level of aquifer restoration prior to implementation of the final remedy. The specific response action objectives of the offpost IRA are:

- Continue current programs for offpost ground-water monitoring and for providing an alternative drinking water supply program to eliminate exposure of residents to contaminated alluvial ground water.

- Mitigate migration of contaminants in alluvial ground water as soon as practicable.

- Treat contaminated alluvial ground water to provide a beneficial impact on ground-water quality.

4.0 GENERAL RESPONSE ACTIONS

Prior to the selection of remedial technologies that may be applicable to offpost conditions and assembly of screened technologies into remedial alternatives, the general response actions for the offpost IRA must be defined. The purpose of the offpost IRA focuses solely on the management of contaminated ground-water migration and reduction or elimination of human exposure to contaminated ground water. Because no contaminant sources are located in the offpost area, no source control measures are relevant. The objectives of the offpost IRA clearly state that other potentially contaminated media such as air, biota, and surface water are not considered pathways in need of interim remediation (Ebasco and others, 1987). Therefore, the alluvial ground-water contaminant transport pathway is the only pathway for which general response actions must be developed.

Although the objectives of the offpost IRA include the need to minimize the potential for human exposure to contaminated ground water, a program supplying bottled water to residents potentially exposed to contaminated water from private drinking-water wells has been in place for several years. Therefore, no imminent threat to human health as a result of consumption of contaminated ground water currently exists. However, the general response actions and resultant remedial alternatives will consider various options available for the continuation of this policy in addition to ground-water treatment.

General response actions for the offpost IRA can be divided into the following four categories:

- No-Action
- Alternative Water Supply
- Management of Contaminant Migration
- Ground-Water Treatment

Consideration of the No-Action response is necessary to determine current baseline conditions. When the No-Action alternative is assembled, the alternative will consist of perpetuation of current offpost operating conditions. This would include continued operation of the NBCS, ground-water monitoring, and supply of bottled water to offpost residents, as necessary.

The Alternative Water Supply response action may be implemented by several mechanisms other than the current method of bottled water supply. Therefore, this response action is considered separate from the No-Action alternative.

The Management of Contaminant Migration category may contain several general response actions. These actions would include ground-water containment, in-situ treatment, offpost ground-water extraction, ground-water treatment, ground-water recharge, or discharge to surface-water bodies.

The Ground-Water Treatment category may also contain several general response actions. These actions would include treatment by carbon adsorption, air stripping, biological treatment, evaporation, oxidation, reverse osmosis, ultrafiltration, in-situ treatment, or some combination of these treatment technologies.

5.0 TECHNOLOGY INVENTORY

The first step in identifying technologies potentially applicable to this IRA for the offpost area is to compile an inventory of available technologies for the general response actions identified in Section 4.0. These potentially applicable technologies are then evaluated to develop a list of appropriate (proven and effective) technologies to meet the interim response objectives of the IRA (Section 3.0). The evaluation criteria include site characteristics, contaminant characteristics, technological limitations, and cost-effectiveness.

As previously discussed, alluvial ground water is the principal contaminated medium of concern for the Offpost IRA. The various extraction, recharge, and treatment technologies applicable to this medium are shown in Table 5-1 and summarized below. This section focuses on technologies that are appropriate for the offpost IRA when considering the IRA objectives and site conditions.

5.1 GROUND-WATER EXTRACTION TECHNOLOGIES

The two basic ground-water extraction technologies that appear to be appropriate for the offpost IRA are pumping wells and subsurface drains. A type of subsurface drain, an open trench drain, is rejected from further consideration because of geotechnical and engineering difficulties associated with keeping the trench open to the depths necessary (approximately 45 feet).

5.1.1 Extraction Wells

Ground-water extraction by wells is a proven technology applicable to the geologic and hydrogeologic conditions in the offpost area. The objectives of the offpost IRA could be satisfied by utilizing any number of well configurations. The final well configuration will be based on site-specific conditions determined in future field investigative efforts or pilot-testing. Because the stated objective of the IRA includes management of contaminant migration, the likely well configuration will include either a well array along the axis of each contaminant plume, an array situated perpendicular to the principal direction of ground-water flow, or a combination of both. Currently, it is sufficient to note that wells are an appropriate remedial technology for management of contaminant migration in the alluvial ground-water system.

5.1.2 Subsurface Drains

Subsurface drains are also a proven technology applicable to offpost conditions. The drains generally act as buried conduits that convey ground-water by gravity flow or in response to pumping. Drains generally affect the water table in much the same way as pumping wells but can be designed to create a continuous zone of depression rather than several overlapping cones of depression as with pumping wells. In heterogenous hydrogeologic environments, this feature of subsurface drains has the potential to make them superior to wells when designing a hydraulic barrier. Additionally, subsurface drains generally have lower operation and maintenance (O&M) costs compared to pumping wells. A disadvantage to drains is that they are generally useful only when attempting to attain ground-water capture across a contaminant plume. That is, they are generally not appropriate when attempting to perform ground-water extraction along the axis of a plume. In those cases, wells are much more appropriate. An additional potential problem associated with subsurface drains is the disposal of large volumes of potentially contaminated soils or ground-water. The large amount of potentially contaminated materials encountered during installation could make this technology cost-prohibitive.

5.2 GROUND WATER RECHARGE (DISPOSAL)

There are three basic methods of disposing ground water after it has been extracted from the subsurface and treated. These methods of disposal include (1) recharge to the aquifer system by wells, ponds or drains; (2) direct discharge to surface-water bodies or courses; and (3) direct discharge to an existing municipal water-supply system. However, because of water-rights issues associated with removal of a resource from one area and disposal to a different area, disposal technologies other than direct recharge to the aquifer in the immediate vicinity of where it was extracted are rejected from further consideration.

Thus, the only appropriate technology for disposal of extracted ground-water is direct recharge by wells, ponds, or drains. If wells are the selected recharge technology, the objectives of the IRA can be met by utilizing any one of numerous well configurations. Additionally, the final design of the recharge well field will also be based on future field investigations, pilot testing, and the extraction well configurations. Based on experience gained at numerous sites across the country and at RMA, it is anticipated that the total number of recharge wells will be approximately twice the number of extraction wells.

Subsurface drains could be constructed to recharge the treated water. Their hydraulic behavior as well as their advantages and disadvantages for incorporation into the offpost IRA are the same as those of drains used for ground-water extraction (Section 5.1.2). However, clogging is a major potential technical problem associated with the use of drains to recharge water. The drains are essentially impossible to rehabilitate once clogging has occurred.

Recharge ponds may also be an applicable recharge technology. The limiting factor for recharge by ponds is the vertical permeability of the surface geologic materials and current near-surface water-table conditions. Because of recent concerns over the high water table in the vicinity of the North Bog, recharge by ponds is rejected from further consideration until it can be shown that it will not have an adverse impact on the water table in the offpost area.

5.3 TREATMENT TECHNOLOGIES

Treatment technologies can be divided into two categories: above-ground technologies and in-situ technologies. A preliminary screening of available treatment technologies has been performed, and only those technologies with documented performance and reliability are considered applicable to this IRA. A number of above-ground treatment technologies appear to be applicable to the offpost IRA. These technologies include activated carbon adsorption, air stripping, biological treatment, evaporation, oxidation, reverse osmosis, and ultrafiltration. Of these above-ground technologies, only activated carbon adsorption has been used extensively at RMA. Thus, the performance and reliability of activated carbon systems are well documented at RMA. In-situ technologies consist of the degradation or transformation of contaminants by microbial populations without extracting the ground-water from the aquifer. Although the technology has been used successfully at a number of sites, it has not been demonstrated at RMA.

5.3.1 Activated Carbon

Activated carbon adsorption is the most widely developed and used technology for treating ground water containing organic chemicals. This process consists of placing raw water in contact with activated carbon, resulting in the organics adsorbing onto the surface of the carbon. The adsorption continues until the carbon is saturated with respect to the chemicals in the raw water.

The adsorption process is driven by the chemical properties of the system and the physical properties of the carbon. The chemical properties of each contaminant determine (1) its respective affinity for the carbon and (2) the overall efficiency of the activated carbon system. Additionally, the high surface area and pore structure of the carbon are prime factors controlling adsorption of organics (CDM, 1986). Generally, activated carbon has been shown to remove most organic compounds from water, with removal efficiencies of from 40 to

99 percent. However, activated carbon is only marginally effective in removing polar chemicals, such as methylene chloride, from water (CDM, 1986; S-R, 1983).

In general, activated carbon systems are not complex to operate. Granular activated carbon is used successfully to treat organics at the NBCS, the Northwest Boundary Containment System (NWBCS), and the Irondale Containment System (ICS). The use of activated carbon in treating contaminated ground-water at RMA also has been the focus of many pilot- and bench-scale testing programs. The operational histories for the various containment systems at RMA and the testing programs have shown that capital and operating costs are moderately high, generally higher than air stripping. The need to regenerate the carbon is the most costly aspect of carbon adsorption.

5.3.2 Air Stripping

Air stripping is an effective and proven technology for removing volatile organics from ground-water. The air stripping process consists of the transfer of volatile contaminants from a liquid phase to a gas phase. The efficiency of this technology is dependent on the chemical properties of the contaminants and the degree to which the air can be kept undersaturated with respect to the contaminants being stripped. The greater the degree of undersaturation, the more efficiently and completely the contaminant will be removed from the water phase.

Air strippers have been used at many sites to effectively remove volatile chlorinated solvents from ground-water. The systems are simple to operate and relatively inexpensive to install and run. The most commonly used, efficient, and economical air stripping system is the packed tower system (CDM, 1986). In the tower, water is trickled down the packing while air is passed through the packing by a blower. Contaminated air is exhausted from the top of the tower, and the treated water is discharged from the tower bottom. If the exhausted air does not meet applicable air-quality standards, additional treatment may be necessary. This requirement will add significantly to the capital and operations costs of the stripping facility.

5.3.3 Biological Treatment

Biological treatment removes organic contaminants through microbial assimilation and degradation. Biological systems can also be utilized to remove some inorganics, such as ammonia and nitrate, from ground-water. The most widely used forms of biological treatment are aerobic systems, although anaerobic systems are also very effective. Biological treatment systems may also be classified as either fixed film systems or suspended growth systems, depending on whether the microorganisms are grown on a surface or suspended in the water. Activated sludge systems are the most commonly used aerobic suspended growth systems. Examples of aerobic fixed film systems include trickling filters and rotating biological contractors. Although certain organic compounds and heavy metals may inhibit biological treatment, the biomass can be acclimated, within limits, to tolerate elevated concentrations of the contaminants (USEPA, 1985). Several factors influence performance of this treatment process, including the chemical properties and concentration of contaminants to be treated, concentration of suspended solids, organic load variations, presence of oil and grease, pH, inorganic water quality, and temperature. In some cases, pretreatment may be necessary for effective results.

Biological treatment has been used at a variety of sites to remove organic contaminants. At RMA, Shell Development Company completed a pilot program for biologically treating chloroform, benzene, and dibromochloropropane. The contaminants were removed at efficiencies greater than 90 percent. However, because offpost ground-water contains chlorinated pesticides that are designed to be persistent in the environment, biodegradation is not expected to be a significant removal mechanism for compounds such as dieldrin or aldrin (USEPA, 1980). Other studies (Matsumura et al, 1978; Bouwer and McCarty, 1984; Bhattacharya and Parkin, 1988; and Wilson, 1981) have shown that microorganisms are capable of biodegrading chlorinated hydrocarbons, although some of these compounds may degrade more rapidly in anaerobic environments than in aerobic environments, but often at slow rates. Biological treatment systems can be very effective, are generally easy to operate , have low capital and operating costs, and are somewhat self-regulating. The waste side streams consist of excess biomass that is generally nontoxic.

5.3.4 Evaporation

Evaporation is a process in which volatile liquids are removed from a waste stream, leaving behind less volatile components. This process is generally used to remove inorganic components from water. Organic compounds can be removed with evaporation; highly volatile species can be volatilized or nonvolatile species can be concentrated. Open ponds are commonly used treatment systems in these cases.

Solar evaporation ponds can be very inexpensive, although if the liquid is considered to be hazardous, a double liner with an intermediate leachate detection system is required (COE, 1987). A further consideration is the potential requirement to replace evaporated water for recharge. Water vapors could be contained and condensed, or replacement water could be purchased from a municipality.

Although a liquid side stream of contaminants is unlikely, vapor or concentrated sludge side streams may be produced.

5.3.5 Oxidation

Oxidation refers to the process of destroying organic matter in a contaminated stream by chemical or thermal means. The products of complete hydrocarbon oxidation are water and carbon dioxide.

Thermal methods of oxidation, such as incineration, are generally not suited for dilute liquid waste streams because of the large amount of energy required to vaporize the bulk liquid. For dilute liquid streams, chemical oxidation is generally preferred. Three commonly used chemical oxidation processes are ozonation, hydrogen peroxide, and potassium permanganate. Oxidation is generally not compound-specific.

Of the three common oxidizing agents (ozone, hydrogen peroxide, and potassium permanganate), ozone is the most powerful oxidant and can therefore achieve the greatest removal percentages (McShea and others, 1986). However, ozonation in itself usually cannot achieve quantitative removal of organics without excessive reaction times or ozone dosages (COE, 1987).

The presence of ultraviolet (UV) radiation catalyzes the reactions and thereby reduces the reactor volume and chemical requirements. As a general rule, the higher the total organic carbon (TOC), the more oxidant and UV energy are required. The actual removal rate for various compounds depends on how easily that compound is oxidized and how readily it absorbs UV radiation (COE, 1987). The final oxidation products generally do not need to be removed from the treated water; thus, no contaminated waste streams are generated by the process.

Oxidation processes are relatively easy to operate, although the capital and operating costs are high. Additional considerations regarding the UV-ozone treatment process are the possibility of (1) incomplete oxidation of all organic contaminants or (2) encountering particularly recalcitrant compounds that resist degradation. In addition, both pretreatment and post-treatment my be required to ensure complete removal of contaminants. In any case, pilot testing to determine optimum operating conditions for the incoming water quality would be necessary.

5.3.6 Reverse Osmosis

Reverse osmosis is a membrane separation process that can reduce concentrations of dissolved organic and inorganic compounds and ions by 90 percent or more (Jhawar and Sleigh, 1975). Osmosis is the natural tendency of water to pass through a semipermeable membrane from the weak solution side to the strong solution side. Pump pressures can be applied to reverse this process and force water from the concentrated side to the pure (permeate) side. The performance of reverse osmosis systems is strongly influenced by the type and configuration of the membranes being used. Pilot testing is often required to determine the best system design for a particular waste stream.

Chemical deterioration of the membranes or fouling and plugging of the flow system may make pretreatment necessary. Prefiltration to at least 5 microns is generally required, and high chloride concentrations may cause corrosion of the process equipment (COE, 1987). The quantity of the side stream produced by this process is approximately 5 to 30 percent of the feed stream.

Reverse osmosis is most often used for inorganic treatments, such as desalination. Treating organics with reverse osmosis poses problems different from those in treating inorganics. Organics tend to adsorb to the membrane surface as much as they are rejected into the concentrated stream. Also, membranes generally stop only compounds with molecular weights greater than 150 to 200. A high total dissolved solids (TDS) content will lead to a large reject stream that would require further treatment (COE, 1987).

5.3.7 Ultrafiltration

Ultrafiltration is a form of filtration that is appropriate for removal of some organics. An ultrafilter is a porous membrane that is permeable to some compounds and impermeable to others. In addition to removing very small particulate matter, the process is also applicable for organic molecules generally ranging in molecular weight from 500 to 500,000 (Weber, 1972). Removal of a substance is related to its molecular shape, size, and flexibility.

Ultrafiltration is similar to reverse osmosis except that much lower feed pressures are used, usually in the range of 5 to 100 pounds per square inch (psi). The process produces a concentrated waste stream that is usually less than 5 percent of the influent volume. As a filtration technique, ultrafiltration is relatively expensive because of its large-particulate pretreatment requirements and costs of the membranes. It is, however, a very effective process for removing many large organic molecules.

5.3.8 In-Situ Treatment

In-situ biorestoration, where applicable, is indicated as a potentially very cost-effective and environmentally acceptable remedial technology. Many contaminants in solution in ground-water as well as vapors in the unsaturated zone can be completely degraded or transformed into new compounds by naturally occurring indigenous microbial populations. In addition to the nature of the contaminant, several environmental factors are known to influence the capacity of indigenous microbial populations to degrade contaminants. These factors include dissolved oxygen, pH, temperature, oxidation-reduction potential, availability of mineral nutrients, salinity, soil moisture, the concentration of specific pollutants, and the nutritional quality of dissolved organic carbon in the ground-water. The limiting factor for this technology is applying the treatment process to the contaminated material. The key to successful remediation is a thorough understanding of the hydrogeologic and geochemical characteristics of the contaminated area.

It is anticipated that this technology would be particularly applicable to the pesticide plumes adjacent to the northern RMA boundary. However, some of the contaminants in the IRA study area, including tetrachloroethane, may not be readily biodegradable (ESE, in progress). Because in-situ systems are generally less reliable than above-ground treatment systems, treatability studies may be necessary to design and maintain a system with an adequate level of performance.

5.4 SUMMARY OF TECHNOLOGY INVENTORY

The technology inventory assembled and evaluated in this section shows that various options exist for meeting the objectives of the IRA. An alternative source of water could be supplied to residents, as necessary, in a number of ways, including a program of supplying bottled water or the installation of one or more deep wells. Hookup to an existing municipal water-supply system is also a viable option, although estimated costs appear to be greatest for this option.

Ground-water extraction and recharge will likely be accomplished using wells or subsurface drains. Both are currently is use at RMA. Based on previous experience at RMA and the objectives of the offpost IRA, wells may be the preferred option; however, a final decision will be made following additional design-level assessments.

Numerous treatment options are available to treat the contaminated alluvial ground water. However, only carbon adsorption has been shown to be a proven technology for the contaminants commonly found in alluvial ground water at RMA. Other technologies, such as ultrafiltration, also may be useful in treating the ground water, but it is likely that carbon adsorption will be the principal treatment option. Limited treatability testing is likely for design of an appropriate treatment process for the ground water.

6.0 ALTERNATIVES DEVELOPMENT

In this section, a preferred remedial alternative is developed from the list of remedial technologies retained in the evaluation process performed in the previous section. The IRA alternative described in this section is expected to meet the IRA objectives described previously. Although the no-action alternative described in this section does not meet all of the IRA objectives, it is included for cost comparison purposes.

Once developed, the technologies for the preferred alternative are evaluated for their relative effectiveness and cost. The goal of these evaluations is to eliminate technologies that do not adequately meet the objectives of the IRA or are an order of magnitude greater in cost but do not provide sufficiently greater benefit in mitigating the migration of contaminants.

6.1 ALTERNATIVES DEVELOPMENT

As previously discussed, the medium of concern is contaminated alluvial ground water. Thus, interim remedial alternatives are assembled to mitigate this medium of concern. The alternatives developed span the range of activity from no action to a system of ground-water extraction, treatment, and recharge, as specified in the proposed Consent Decree. A ground-water monitoring component is included in all alternatives as is an alternative supply of water to residents. The no-action alternative is included in the alternatives development for cost comparison purposes.

The following sections describe the possible components of the alternative developed for the offpost IRA. The discussions are organized into three separate sections that describe appropriate options for (1) alternative water supply, (2) ground-water extraction and recharge, and (3) treatment alternatives. In general, the options described are conceptual and no attempt is made to develop specific remedial alternatives in this document. Specific remedial alternatives and attending technologies will be identified and evaluated in the IRA Implementation Document.

6.1.1 No-Action Alternative

The no-action alternative represents the current program for the offpost area. This alternative involves continued supply of bottled water to consumptive users and continuation of the Comprehensive Monitoring Program (CMP) in the offpost area. As such, the no-action alternative does not provide for management of contaminated ground-water migration. Thus, this alternative does not completely satisfy the IRA objectives.

The current program of supplying bottled water to area residents, as necessary, has been in place for a number of years, although only one family is currently being supplied with bottled water. The bottled water supplied to this family is being provided by Shell. The program is effective in eliminating the consumptive exposure pathway (drinking and cooking). If the program is continued as part of the IRA, the exact supply of bottled water would be adjusted as appropriate.

The existing CMP provides for semi-annual collection and analysis of ground-water samples from approximately 78 offpost wells. Sampling of these wells and an additional number of consumptive use sources would be continued, and the total number of wells to be monitored would be modified as appropriate. For the IRA, with an expected life of at least five years, it is anticipated that wells may be added or deleted as a result of the effects of other remedial activities. For costing purposes, it was assumed that the current CMP or a similar program would continue during the life of the IRA (a minimum of five years).

Table 6-1 shows the estimated costs for the no-action alternative. As shown, the annual costs are approximately $710,000 for the monitoring program and $44,000 for supplying bottled water. Capital costs for these component activities are minimal.

Table 6-1: No-Action Alternative*
(Monitoring, Continue Supplying Bottled Water)

	Capital Costs	Annual O&M Costs
Monitoring Program (236 samples) (19 wells quarterly and 80 wells semi-annually)	$ 0	$710,000
Bottled water (10 quarts/person/day) (48 people)	1,000	44,000

*Source: ESE, 1987

Assumptions: 16 potentially affected households and 3 persons per household

6.1.2 Alternative Water-Supply Options

There are five appropriate options for providing an alternative water supply to potentially exposed populations in the offpost area. Table 6-2 shows the alternatives for supplying an alternative source of water and the associated estimated costs.

The first alternative is providing bottled water. This is essentially the same as the program described in the no-action alternative discussed above. Four other alternatives for supplying an alternative source of water are (1) hooking-up all potentially exposed households to an existing municipal water supply, (2) installing a central deep well (Arapahoe Formation well), (3) point-of-use treatment, and (4) installing a deep well at each household.

Each of these five options meets the objective of eliminating the consumptive exposure pathway. However, the option of supplying bottled water does not eliminate other potential routes of exposure, such as bathing. The four remaining alternatives would likely achieve this goal. Costs for achieving this goal span a wide range. The least expensive alternative is the point-of-use treatment option, with capital costs of $130,000 and annual O&M costs of $32,000. Hookup to a municipal water-supply system or installation of a central Arapahoe Formation well and associated piping have capital costs of approximately $1,000,000, with minor annual O&M. These costs are greatly affected by piping costs.

6.1.3 Ground-Water Extraction and Recharge Options

The final alternative selected for the IRA will incorporate ground-water extraction and recharge systems. The purpose of these systems is to remove chemicals from the ground-water system and begin to remediate the aquifer system prior to implementation of the final remedy. These systems would also utilize a treatment component as described in Section 6.1.4. Table 6-3 shows costs associated with ground-water extraction and recharge. For costing purposes, it was assumed that a total of approximately 20 extraction wells and 40 injection wells would be utilized to address contaminant migration along both pathways. Additionally,

Table 6-2: Alternative Water-Supply Options

	Capital Costs	Annual O&M Costs
Bottled water* (10 quarts/person/day) (48 people)	$ 1,000	$44,000
Hook-up to municipal water supply (16 households)	1,100,000	5,000
Install a central deep well and associated piping (Arapahoe Formation well), maintenance/rehabilitation and electrical costs	1,000,000	6,000
Wellhead treatment (16 households)	130,000	32,000
Install a deep well and associated piping (Arapahoe Formation Well) at each household (16 households)	930,000	32,000

*Source: ESE, 1987

Assumptions: 16 potentially affected households and 3 persons per household

Table 6-3: Extraction and Recharge Options

	Capital Costs	Annual O&M Costs
Extraction		
Wells (assume 20 wells)	$ 200,000	$ 0
Drains (assume 4000 linear feet)	1,600,000	10,000
Piping and pumps*	33,000	0
Electrical costs*	0	36,000
Well maintenance/rehabilitation	0	5,000
Recharge		
Wells (assume 40 wells)	$ 400,000	$ 0
Drains (assume 4000 linear feet)	1,600,000	10,000
Piping and pumps	66,000	0
Electrical costs	0	72,000
Well maintenance/rehabilitation	0	10,000

*Source: ESE, 1987

Assumptions: Offpost Treatment Facility and a combined flow rate of 300 gpm along both paleochannels the costs for drains assumes that approximately 4000 linear feet of drain will be installed. These estimates are based on an assumed combined flow rate along both pathways of 300 gallons per minute (gpm).

6.1.3.1 Extraction Options

Extraction wells and subsurface drains appear to be feasible for ground-water extraction. Wells are currently in use for ground-water extraction at all three operating boundary containment systems. However, unlike the existing containment systems, the migration management aspect of the offpost IRA will not include a physical barrier. Physical barriers are excluded from the IRA because they are permanent structures that will affect ground-water flow direction and velocities and could interfere with the final remedy. Although not currently in use at RMA, subsurface drains also are a viable technology for ground-water extraction.

The exact configuration of an extraction well field for the IRA, including the number and locations of the extraction wells, will be set forth in future design documents, as described in Section 1.3. The design would be based in part on results obtained from additional hydrogeologic investigations.

The conceptual design of the extraction well field consists of wells located along the axes of the offpost contaminant plumes, extending from the vicinity of the NBCS to O'Brian Canal, although many other configurations are possible. The extraction system may also consist of one or more lines of wells oriented perpendicular to the principal direction of ground-water flow. Locating wells along the axes of the plumes would maximize the rate at which contaminants are removed from the aquifer system for a given number of wells. This would expedite the removal of chemicals along the axes of the plumes and increase the efficiency of the IRA.

If the number of wells required for the extraction well field is significant, subsurface drains may be more cost-effective. Technically, the drains are comparable to wells in their ability to intercept ground-water flow. However, because drains are generally appropriate only for interception systems oriented perpendicular to the ground-water flow direction, and depending on the preferred configuration for an extraction system, subsurface drains may not be appropriate for the offpost IRA. For example, if it is determined that the extraction system is to be oriented along the axes of the plumes, drains would not be a viable alternative.

For cost comparison purposes, it is assumed that approximately 20 extraction wells would be sufficient to meet the IRA objectives. The estimated costs for such a system are $233,000 in capital costs and $40,000 in annual O&M. The cost for extraction by subsurface drains is considerably more, $1,600,000 in capital costs and $10,000 in annual O&M. These costs are based on slightly different assumptions for the two extraction well configurations. For wells, it was assumed that 10 wells along the axis of each paleochannel would be sufficient to meet the IRA objective of removing chemicals from the aquifer and mitigating contaminant migration. For subsurface drains, it was assumed that a single drain located on each channel would be necessary, extending across the width of each paleochannel as currently defined. This configuration would require approximately 4000 feet of drain, depending on the width of the plume at each location. This shows an additional difficulty with subsurface drains as an extraction alternative; that is, they are generally not appropriate if it is desired to extract ground water at many locations along the axis of a plume. For these configurations, wells are technically superior and are more cost-effective.

The final extraction alternative will likely consist of extraction wells, subsurface drains, or a combination of both to intercept and remove contaminated ground water. These are proven mechanisms that can achieve the objectives of the IRA.

6.1.3.2 Recharge Options

Recharge by wells, ponds, or drains has been considered. As shown in Table 6-3, recharge by wells is expected to be significantly more cost-effective than recharge utilizing subsurface drains. A ground-water recharge system employing 40 recharge wells would cost approximately $500,000 in capital costs and nearly $100,000 in annual O&M. This is less than the approximately $1,600,000 cost for recharge by subsurface drains alone. Although these estimates are based on several assumptions that require verification at a later date, they provide some indication of the significantly greater costs associated with subsurface drains. Conversely, wells are readily rehabilitated. It is highly unlikely that recharge wells would need to be replaced as a result of simple clogging problems. A number of physical and chemical techniques are available to rehabilitate the well screen and filter pack.

There are several technical and operational disadvantages to using subsurface drains as recharge structures. These problems are associated with the inability to adequately rehabilitate the drain back-fill materials. As ground water is recharged, carbon fines, biological growth, or other particulate matter is introduced, causing clogging of the drain back-fill. Eventually, this results in significantly reduced recharge rates. These clogging materials generally cannot be removed and may ultimately necessitate that the drain be abandoned and replaced by other recharge facilities.

Thus, for cost-effectiveness and long-term technical feasibility, it appears that recharge wells are superior to the other recharge alternatives evaluated. The final recharge alternative will likely consist of recharge wells. The final configuration of the recharge well field, including the number of recharge wells, will depend on the aquifer properties, locations of the extraction wells or drains, and desired flow rates.

6.1.4 Treatment Options

The treatment options will be compared and evaluated on the basis of their ability to remove organic chemicals from ground water. The time required to develop and pilot test an inorganic treatment system would unnecessarily delay the implementation of this IRA and is not consistent with the interim action goal of achieving significant beneficial effects in the near term. With the exception of fluoride, inorganic species are of concern only with respect to possible scaling and fouling problems in the process equipment. For purposes of this discussion, scaling and fouling problems are assumed to be insignificant. However, final treatment system design will consider this potential difficulty.

Carbon adsorption is a proven treatment process for removal of organic compounds, although it will not efficiently remove polar compounds such as methylene chloride. Activated carbon systems are not complex, are easy to operate, require no pilot studies, and could be readily implemented. Activated carbon systems currently operating at RMA show that such a system would be effective in removing the majority of contaminants detected in offpost ground water.

Air stripping is also a proven treatment process for removing organics from water. As shown in Table 6-4, this treatment process is generally less expensive than activated carbon. However, several of the contaminants detected in offpost ground water, including endrin, chlorophenylmethyl sulfone, and chloromethylphenyl sulfoxide, will not be readily removed from ground water by air stripping. Based on these limitations, it is unlikely that air stripping could be used without additional treatment processes. Air stripping is not currently being used at RMA, and pilot testing is considered necessary before it could be implemented. Air stripping is therefore not considered a viable treatment technology for the IRA.

6.2 ALTERNATIVE SELECTION

The preferred alternative for the offpost IRA incorporates:

Table 6-4: Treatment Options

	Capital Costs	Annual O&M Costs
Air Stripping System*	$150,000	$ 15,000
Carbon Adsorption System**	670,000	200,000

*Source: Bevrit and others, 1988
**Source: ESE, 1987

Assumptions: Treatment stream of 300 gpm

- Alternative water supply
- Ground-water monitoring
- Ground-water extraction, treatment, and recharge systems

Figure 6-1 shows the area to be addressed by the IRA. The design life of this IRA is estimated to be at least five years, based on the expected time required to implement the final remedy. The IRA alternative to be implemented will be designed to be readily expandable to accommodate larger flows or alternative technologies in support of or for inclusion in the final remedy.

The most cost-effective alternative for meeting the objectives of the IRA consists of providing an alternative water supply through continuation of the bottled water supply program or the installation of a central supply well. The CMP ground-water monitoring program should be continued to permit evaluation of the ground-water quality in the affected area. The extraction and recharge components of the preferred alternative consist of a series of wells located within the confines of the ground-water plume. The number of wells and their locations cannot be determined at this time. Additional hydrogeologic investigations will be conducted to collect the necessary data for system design and implementation.

The recommended treatment option consists of a carbon adsorption unit followed by filtration to remove fines. This treatment process is relatively simple to operate and is cost-effective. These technologies have been proven effective and reliable at the operational boundary containment systems at RMA. The use of a filtration process following the carbon adsorption unit may be necessary and will be evaluated in the design phase documents. It is unlikely that the remaining treatment technologies could be used individually to adequately treat ground water; thus, they have not been costed for the IRA. Some of the technologies, however, may be part of the final preferred alternative for the IRA. Ultrafiltration, for example, may be necessary to remove fines from the treatment stream prior to

EXPLANATION

Boundary Containment System

RMA Boundary

IRA Study Area Boundary

Area Of Unsaturated Alluvium

Area Of Alluvial Contamination

Primary Ground-Water Flow Path

Figure 6-1
AREA IN WHICH ALLUVIAL CONTAMINATION WILL BE ADDRESSED BY OFFPOST IRA

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U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

recharge. This will help reduce the chances of severe clogging problems that would reduce the ability of the system to recharge the extracted ground water. Other possible ancillary treatment technologies will be considered in the final design phase for the IRA.

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APPENDIX A

POTENTIAL
CHEMICAL-SPECIFIC ARARs FOR
THE ENDANGERMENT ASSESSMENT FOR THE
OFF-POST OPERABLE UNIT, RMA

POTENTIAL
CHEMICAL-SPECIFIC ARARS FOR
THE ENDANGERMENT ASSESSMENT FOR THE
OFF-POST OPERABLE UNIT
ROCKY MOUNTAIN ARSENAL

1. PRIMARY NAME: Acetone (Dimethyl ketone)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

2. PRIMARY NAME: Aldrin
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 129.100(a)(3) (TPES) -- 0.003 $\mu g/l$;
(b) 45 Fed. Reg. 79325 (1980) (AWQC) -- 0.74 ng/l (10^{-5}), 0.074 ng/l (10^{-6}), 0.0074 ng/l (10^{-7}) (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 129.100(a)(3) (TPES) -- 0.003 $\mu g/l$;
(b) 45 Fed. Reg. 79325 (1980) (AWQC) -- 0.74 ng/l (10^{-5}), 0.074 ng/l (10^{-6}), 0.0074 ng/l (10^{-7}) (Human Health);
(c) 45 Fed. Reg. 79325 (1980) (AWQC) -- 3 $\mu g/l$ (Aquatic Life).

Biota RI Analyte: Yes
Potential Biota ARAR: No

3\. <u>PRIMARY NAME</u>: Arsenic
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR:
(a) 40 C.F.R. § 61.162(a)(1) (NESHAP) -- uncontrolled total arsenic emissions from existing glass melting furnaces shall be less than 2.5 Mg per year;
(b) 40 C.F.R. § 61.162(b)(1) (NESHAP) -- uncontrolled total arsenic emissions from new or modified glass melting furnaces shall be less than 0.4 Mg per year.

Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 μg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 μg/l;
(c) 45 Fed. Reg. 79325-79326 (1980) (AWQC) -- 22 ng/l (10^{-5}), 2.2 ng/l (10^{-6}), 0.22 ng/l (10^{-7}) (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 μg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 μg/l;
(c) 45 Fed. Reg. 79325-79326 (1980) (AWQC) -- 22 ng/l (10^{-5}), 2.2 ng/l (10^{-6}), 0.22 ng/l (10^{-7}) (Human Health);
(d) 45 Fed. Reg. 79325 (1980) (AWQC) -- 440 μg/l (Aquatic Life).

Biota RI Analyte: Yes
Potential Biota ARAR: No

4. <u>PRIMARY NAME</u>: Arsenic chloride (AT)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Arsenic)
Potential Air ARAR: (a) 40 C.F.R. § 61.162(a)(1) (NESHAP) (Arsenic) -- uncontrolled total arsenic emissions from existing glass melting furnaces shall be less than 2.5 Mg per year;
(b) 40 C.F.R. § 61.162(b)(1) (NESHAP) (Arsenic) -- uncontrolled total arsenic emissions from new or modified glass melting furnaces shall be less than 0.4 Mg per year.

Ground Water RI Analyte: Yes (Arsenic)
Potential Ground Water ARAR: (a) (Arsenic) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 µg/l;
(b) (Arsenic) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 µg/l;
(c) (Arsenic) 45 Fed. Reg. 79325-79326 (1980) (AWQC) -- 22 ng/l (10^{-5}), 2.2 ng/l (10^{-6}), 0.22 ng/l (10^{-7}) (Human Health).
Soil RI Analyte: Yes (Arsenic)
Soil EA Analyte: Yes (Arsenic)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Arsenic)
Potential Surface Water ARAR: (a) (Arsenic) 40 C.F.R. § 141.11(b) (NPDW --MCL) -- 50 µg/l;
(b) (Arsenic) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 µg/l;
(c) (Arsenic) 45 Fed. Reg. 79325-79326 (1980) (AWQC) -- 22 ng/l (10^{-5}), 2.2 ng/l (10^{-6}), 0.22 ng/l (10^{-7}) (Human Health);
(d) (Arsenic) 45 Fed. Reg. 79325 (1980) (AWQC) -- 440 µg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

5. <u>PRIMARY NAME</u>: Arsenic trioxide (ATO)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Arsenic)
Potential Air ARAR: (a) (Arsenic) 40 C.F.R. § 61.162(a)(1) (NESHAP) -- uncontrolled total arsenic emissions from existing glass melting furnaces shall be less than 2.5 Mg per year;
(b) (Arsenic) 40 C.F.R. § 61.162(b)(1) (NESHAP) -- uncontrolled total arsenic emissions from new or modified glass melting furnaces shall be less than 0.4 Mg per year.

Ground Water RI Analyte: Yes (Arsenic)
Potential Ground Water ARAR: (a) (Arsenic) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 $\mu g/l$;
(b) (Arsenic) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 $\mu g/l$;
(c) (Arsenic) 45 Fed. Reg. 79325-79326 (1980) (AWQC) -- 22 ng/l (10^{-5}), 2.2 ng/l (10^{-6}), 0.22 ng/l (10^{-7}) (Human Health);
Soil RI Analyte: Yes (Arsenic)
Soil EA Analyte: Yes (Arsenic)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Arsenic)
Potential Surface Water ARAR: (a) (Arsenic) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 $\mu g/l$;
(b) (Arsenic) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 $\mu g/l$;
(c) (Arsenic) 45 Fed. Reg. 79325-79326 (1980) (AWQC) -- 22 ng/l (10^{-5}), 2.2 ng/l (10^{-6}), 0.22 ng/l (10^{-7}) (Human Health);
(d) (Arsenic) 45 Fed. Reg. 79325 (1980) (AWQC) -- 440 $\mu g/l$ (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

6. PRIMARY NAME: Benzene
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.61(a), 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 5 µg/l;
(b) 45 Fed. Reg. 79326 (1980) (AWQC) -- 6.6 µg/l (10^{-5}), 0.66 (10^{-6}), 0.066 (10^{-7}) (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. §141.61(a); 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 5 µg/l;
(b) 45 Fed. Reg. 79326 (1980) (AWQC) -- 6.6 µg/l (10^{-5}), 0.66 (10^{-6}), 0.066 (10^{-7}) (Human Health);
(c) 45 Fed. Reg. 79326 (1980) -- 5,300 µg/l (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

7. PRIMARY NAME: Cadmium
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 10 μg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 10 μg/l;
(c) 45 Fed. Reg. 79327 (1980) (AWQC) -- 10 μg/l (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 10 μg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 10 μg/l;
(c) 45 Fed. Reg. 79327 (1980) (AWQC) -- 10 μg/l (Human Health);
(d) 45 Fed. Reg. 79326-79327 (1980) (AWQC) -- 24 hour average to be determined by e (1.05 [In(hardness)]-8.73), but not to exceed value of e (1.05 [In(hardness)]-3.73) at any one time (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

8. PRIMARY NAME: Calcium
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

9. PRIMARY NAME: Calcium bromate (Bromic acid, calcium salt)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Calcium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Calcium)
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

10. PRIMARY NAME: Calcium carbide
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Calcium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Calcium)
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

11. PRIMARY NAME: Calcium chloride
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Calcium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Calcium)
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

12. <u>PRIMARY NAME</u>: Carbon tetrachloride (Perchloromethane, Tetrachloromethane)

CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: (a) 40 C.F.R. § 141.61(a), 42 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 5 $\mu g/l$; (b) 45 Fed. Reg. 79327 (1980) (AWQC) -- 4.0 $\mu g/l$ (10^{-5}), 0.40 $\mu g/l$ (10^{-6}), 0.04 $\mu g/l$ (10^{-7}) (Human Health).
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 40 C.F.R. § 141.61(a), 42 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 5 $\mu g/l$; (b) 45 Fed. Reg. 79327 (1980) (AWQC) -- 4.0 $\mu g/l$ (10^{-5}), 0.40 $\mu g/l$ (10^{-6}), 0.04 (10^{-7}) (Human Health); (c) 45 Fed. Reg. 79327 (1980) (AWQC) -- 35,200 $\mu g/l$ (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

13. <u>PRIMARY NAME</u>: Chloride

CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

14. PRIMARY NAME: Chlorinated phenol

CERCLA Hazardous Substance: Yes

Ranking on ATSDR Priority List: Priority Group 4 (2,4,6-Trichlorophenol and 2,4-Dichlorophenol)

Air Analyte: No

Potential Air ARAR: No

Ground Water RI Analyte: No

Potential Ground Water ARAR:

(a) 2,4,5-trichlorophenol -- 45 Fed. Reg. 79329 (1980) (AWQC) -- 2600 $\mu g/l$ (Human Health);

(b) 2,4,6-trichlorophenol -- 45 Fed. Reg. 79329 (1980) (AWQC) -- 12 $\mu g/l$ (10^{-5}), 1.2 $\mu g/l$ (10^{-6}), 0.12 $\mu g/l$ (10^{-7}) (Human Health);

(c) Sufficient data was not available to derive AWQC toxicity levels for other compounds that would be protective of human health, 45 Fed. Reg. 79329 (1980).

Soil RI Analyte: No

Soil EA Analyte: No

Potential Soil ARAR: No

Surface Water RI Analyte: No

Potential Surface Water ARAR:

(a) 2,4,5-trichlorophenol -- 45 Fed. Reg. 79329 (1980) (AWQC) -- 2600 $\mu g/l$ (Human Health);

(b) 2,4,6-trichlorophenol -- 45 Fed. Reg. 79329 (1980) (AWQC) -- 12 $\mu g/l$ (10^{-5}), 1.2 $\mu g/l$ (10^{-6}), 0.12 $\mu g/l$ (10^{-7}) (Human Health);

(c) Sufficient data was not available to derive AWQC toxicity levels for other compounds that would be protective of human health, 45 Fed. Reg. 79329 (1980);

(d) 4-chloro-3-methyphenol, 45 Fed. Reg. 79329 (1980) (AWQC) -- 30 $\mu g/l$ (Aquatic Life);

(e) 2,4,[illegible]trichlorophenol, 45 Fed. [illegible]g. 79329 (1980) (AWQC) -- 970 $\mu g/l$ (Aquatic Life);

(f) Other chlorinated phenols, 45 Fed. Reg. 79329 (1980) (AWQC) -- 500,000 $\mu g/l$ (Aquatic Life).

Biota RI Analyte: No

Potential Biota ARAR: No

15. PRIMARY NAME: Chlorobenzene (Monochlorobenzene)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 3
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 45 Fed. Reg. 79327-79328 (1980) (AWQC-Monochlorobenzene) -- 488 μg/l (Human Health)
Soil RI Analyte: Yes (Benzene)
Soil EA Analyte: Yes (Benzene)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Benzene)
Potential Surface Water ARAR:
(a) 45 Fed. Reg. 79327-79328 (1980) (AWQC-Monochlorobenzene) -- 488 μg/l (Human Health);
(b) 45 Fed. Reg. 79327 (1980) (AWQC) -- 50 μg/l (7.5 days exposure) (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

16. <u>PRIMARY NAME</u>: Chloroform (Trichloromethane)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.12 (NPDW -- MCL) -- 100 $\mu g/l$ (<u>Note</u> this is the total combined limit for this and all other trihalomethanes);
(b) 45 Fed. Reg. 79330 (1980) (AWQC) -- 1.9 $\mu g/l$ (10^{-5}), 0.19 $\mu g/l$ (10^{-6}), 0.019 $\mu g/l$ (10^{-7}) (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.12 (NPDW -- MCL) -- 100 $\mu g/l$ (<u>Note</u> this is the total combined limit for this and all other trihalomethanes);
(b) 45 Fed. Reg. 79330 (1980) (AWQC) -- 1.9 $\mu g/l$ (10^{-5}), 0.19 $\mu g/l$ (10^{-6}), 0.019 $\mu g/l$ (10^{-7}) (Human Health);
(c) 45 Fed. Reg. 79330 (1980) (AWQC) -- 1240 $\mu g/l$ (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

17. <u>PRIMARY NAME</u>: p-Chlorophenyl methyl sulfide (CPMS, PCPMS)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (2-Chlorophenol) 45 Fed. Reg. 79330 (1980) (AWQC) -- 4380 μg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

18. <u>PRIMARY NAME</u>: p-Chlorophenyl methyl sulfone ($CPMSO_2$, $PCPMSO_2$)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (2-Chlorophenol) 45 Fed. Reg. 79330 (1980) (AWQC) -- 4380 μg/l (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

19. PRIMARY NAME: p-Chlorophenyl methyl sulfoxide (CPMSO, PCPMSO)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (2-Chlorophenol) 45 Fed. Reg. 79330 (1980) (AWQC) -- 4380 μg/l (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

20. PRIMARY NAME: Chromium
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: (a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 μg/l; (b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 μg/l.
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 μg/l; (b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 μg/l.
Biota RI Analyte: No
Potential Biota ARAR: No

21. PRIMARY NAME: Chromium III
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Chromium)
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Chromium)
Potential Ground Water ARAR: 45 Fed. Reg. 79331 (1980) (AWQC) -- 0.170 $\mu g/l$ (Human Health)
Soil RI Analyte: Yes (Chromium)
Soil EA Analyte: Yes (Chromium)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Chromium)
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79331 (1980) (AWQC) -- 0.170 $\mu g/l$ (Human Health);
(b) 45 Fed. Reg. 79331 (1980) (AWQC) -- to be determined by e (1.08 [In(hard - ness)] + 3.48) (Aquatic Life.
Biota RI Analyte: No
Potential Biota ARAR: No

22. PRIMARY NAME: Chromium VI
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Chromium)
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Chromium)
Potential Ground Water ARAR: 45 Fed. Reg. 79331 (1980) (AWQC) -- 50 $\mu g/l$ (Human Health)
Soil RI Analyte: Yes (Chromium)
Soil EA Analyte: Yes (Chromium)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Chromium)
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79331 (1980) (AWQC) -- 50 $\mu g/l$ (Human Health);
(b) 45 Fed. Reg. 79331 (1980) (AWQC) -- 24 hour average to be determined by e (1.08 [In(hard - ness)] + 3.48) (Aquatic Life.
Biota RI Analyte: No
Potential Biota ARAR: No

23. PRIMARY NAME: Copper
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 3
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 21 C.F.R. § 193.90 (TPFA) -- tolerance of 1 part per million for potable water for residues of copper resulting from the use as algicides or herbicides of basic copper carbonate (molachite), copper sulfate (see below), copper monoethandime, and copper to control aquatic plants in reservoirs, lakes, ponds, irrigation ditches and other potential sources of potable water.
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 21 C.F.R. § 193.90 (TPFA) -- tolerance of 1 part per million for potable water for residues of copper resulting from the use as algicides or herbicides of basic copper sulfat[illegible] and the other copper [illegible]pounds cited in "Pot[illegible]ial Ground Water ARAR" above) to control aquatic plants in reservoirs, lakes, ponds, irrigation ditches and other potential sources of potable water;
(b) 45 Fed. Reg. 79331 (1980) (AWQC) -- 24 hour average is 5.6 μg/l and concentration at any one time should not exceed e (0.94 [In(hardness)]-1.23) (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

24. PRIMARY NAME: Copper sulfate
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Copper)
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Copper)
Potential Ground Water ARAR: 21 C.F.R. § 193.90 (TPFA) -- tolerance of 1 part per million for potable water for residues of copper resulting from the use as algicides or herbicides of basic copper carbonate (molachite), copper sulfate (see below), copper monoethandime, and copper to control aquatic plants in reservoirs, lakes, ponds, irrigation ditches and other potential sources of potable water.
Soil RI Analyte: Yes (Copper)
Soil EA Analyte: Yes (Copper)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:

(a) 21 C.F.R. § 193.90 (TPFA) -- tolerance of 1 part per million for potable water for residues of copper resulting from the use as algicides or herbicides of basic copper sulfate (and the other copper compounds cited in "Potential Ground Water ARAR" above) to control aquatic plants in reservoirs, lakes, ponds, irrigation ditches and other potential sources of potable water;

(b) 45 Fed. Reg. 79331 (1980) (AWQC) -- 24 hour average is 5.6 μg/l and concentration at any one time should not exceed e (0.94 [In(hardness)]-1.23) (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

25. PRIMARY NAME: DDE (p, p'-Dichlorodiphenylethene)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 40 C.F.R. § 129.101(a)(3) (TPES) -- 0.001 µg/l
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 40 C.F.R. § 129.101(a)(3) (TPES) -- 0.001 µg/l; (b) 45 Fed. Reg. 79331 (1980) (AWQC) -- 1,050 µg/l (Aquatic Life).
Biota RI Analyte: Yes
Potential Biota ARAR: No

26. PRIMARY NAME: DDT (p,p'-Dichlorodipenyltrichloroethane)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: (a) 40 C.F.R. § 129.101(a)(3) (TPES) -- 10 µg/l; (b) 45 Fed. Reg. 79332 (1980) (AWQC) -- 0.24 ng/l (10^{-5}), 0.024 ng/l (10^{-6}), 0.0024 ng/l (10^{-7}) (Human Health).
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 40 C.F.R. § 129.101(a)(3) (TPES) -- 10 µg/l; (b) 45 Fed. Reg. 79332 (1980) (AWQC) -- 0.24 ng/l (10^{-5}), 0.024 ng/l (10^{-6}), 0.0024 ng/l (10^{-7}) (Human Health); (c) 45 Fed. Reg. 79331 (1980) (AWQC) -- 24 hour average is 0.0010 µg/l and 1.1 µg/l at any one time (Aquatic Life).
Biota RI Analyte: Yes
Potential Biota ARAR: No

27. <u>PRIMARY NAME</u>: 1,2-Dibromo-3-chloropropane (DBCP, Nemagon, Dibromochloropropane)

CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: 21 C.F.R. § 193.250(a) (TPFA) -- When food additive is present as a result of fumigation in addition to the authorized use of this nematocide, the total residues of inorganic bromides shall not exceed the following: (i) 400 parts per million in or on dried eggs and processed herbs and spices;...(ii.) 250 parts per million in or on concentrated tomato products and dried figs; and (iv) 125 parts per million in or on processed foods other than those listed above.

28. PRIMARY NAME: p-Dichlorobenzene (1,4-Dichlorobenzene)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: (a) 40 C.F.R. § 141.50(b) (NPDW -- MCLG) -- 750 µg/l; (b) 45 Fed. Reg. 79332 (1980) (AWQC) -- 400 µg/l (Human Health)
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: (a) 40 C.F.R. § 141.50(b) (NPDW -- MCLG) -- 750 µg/l; (b) 45 Fed. Reg. 79332 (1980) (AWQC) -- 400 µg/l (Human Health); (c) 45 Fed. Reg. 79332 (1980) (AWQC) -- 763 µg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

29. PRIMARY NAME: 1,1-Dichloroethane
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 3
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

30. PRIMARY NAME: 1,2-Dichloroethane
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 40 C.F.R. § 141.61(a) (NPDW -- MCL); 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) -- 5 μg/l
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: 40 C.F.R. § 141.61(a); 52 Fed. Reg. 25716 (1987) (effective Jan 9, 1989) -- 5 μg/l
Biota RI Analyte: No
Potential Biota ARAR: No

31. <u>PRIMARY NAME</u>: 1,1-Dichloroethylene
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.61(a), 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 7 μg/l;
(b) 40 C.F.R. § 141.50(b) (NPDW -- MCLG) -- 7 μg/l;
(c) 45 Fed. Reg. 79332 (1980) (AWQC) -- 0.33 μg/l (10^{-5}), 0.033 μg/l (10^{-6}), 0.0033 μg/l (10^{-7}) (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.61(a), 52 Fed. Reg. 25716 (1987) (effective Jan 9, 1989) (NPDW -- MCL) -- 7 μg/l;
(b) 40 C.F.R. § 141.50(b) (NPDW -- MCLG) -- 7 μg/l;
(c) 45 Fed. Reg. 79332 (1980) (AWQC) -- 0.33 μg/l (10^{-5}), 0.033 μg/l (10^{-6}), 0.0033 μg/l (10^{-7}) (Human Health);
(d) 45 Fed. Reg. 79332 (1980) (AWQC) -- 11,600 μg/l (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

32. <u>PRIMARY NAME</u>: 1,2-Dichloroethylene
CFRCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.61(a), 52 Fed. Reg. 25716 (1987) (effective Jan 9, 1989) (NPDW -- MCL) -- 7 $\mu g/l$;
(b) 45 Fed. Reg. 79332 (1980) (AWQC) -- 0.33 $\mu g/l$ (10^{-5}), 0.033 $\mu g/l$ (10^{-6}), 0.0033 $\mu g/l$ (10^{-7}) (Human Health);

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.61(a), 52 Fed. Reg. 25716 (1987) (effective Jan 9, 1989) (NPDW -- MCL) -- 7 $\mu g/l$;
(b) 45 Fed. Reg. 79332 (1980) (AWQC) -- 0.33 $\mu g/l$ (10^{-5}), 0.033 $\mu g/l$ (10^{-6}), 0.0033 $\mu g/l$ (10^{-7}) (Human Health);
(c) 45 Fed. Reg. 79332 (1980) (AWQC) -- 11,600 $\mu g/l$ (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

33. <u>PRIMARY NAME</u>: Dicyclopentadiene (DCPD)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

34. <u>PRIMARY NAME</u>: Dieldrin

CERCLA Hazardous Substance: Yes

Ranking on ATSDR Priority List: Priority Group 1

Air Analyte: Yes

Potential Air ARAR: No

Ground Water RI Analyte: Yes

Potential Ground Water ARAR:
(a) 40 C.F.R. § 129.100(a)(3) (TPES) -- 0.12 μg/l;
(b) 45 Fed. Reg. 79325 (1980) (AWQC) -- 0.71 ng/l (10^{-5}), 0.071 ng/l (10^{-6}), 0.0071 ng/l (10^{-7}) (Human Health).

Soil RI Analyte: Yes

Soil EA Analyte: Yes

Potential Soil ARAR: No

Surface Water RI Analyte: Yes

Potential Surface Water ARAR:
(a) 40 C.F.R. § 129.100(a)(3) (TPES) -- 0.12 μg/l;
(b) 45 Fed. Reg. 79325 (1980) (AWQC) -- 0.71 ng/l (10^{-5}), 0.071 ng/l (10^{-6}), 0.0071 ng/l (10^{-7}) (Human Health);
(c) 45 Fed. Reg. 79325 (1980) (AWQC) -- 24 hour average 0.0019 μg/l and concentration of 2.5 μg/l at any one time (Aquatic Life).

Biota RI Analyte: Yes

Potential Biota ARAR: No

35. PRIMARY NAME: Diisopropyl methyl phosphonate (DIMP, Diisopropylmethylphosphonate)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

36. PRIMARY NAME: 1,4-Dithiane (DITH)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

37. PRIMARY NAME: Endrin
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 3
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.12 (NPDW -- MCL) -- 0.2 µg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 0.2 µg/l;
(c) 45 Fed. Reg. 79334 (1980) (AWQC) -- 1 µg/l (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.12 (NPDW -- MCL) -- 0.2 µg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 0.2 µg/l;
(c) 45 Fed. Reg. 79334 (1980) (AWQC) -- 1 µg/l (Human Health);
(d) 45 Fed. Reg. 79334 (1980) (AWQC) -- 24 hour average 0.0023 µg/l and concentration not to exceed 0.18 µg/l at any time (Aquatic Life).

Biota RI Analyte: Yes
Potential Biota ARAR: 40 C.F.R. § 180.131 (TPCRAC) -- zero parts per million tolerances for residues in sugarbeets, sugarbeet tops, broccoli, brussels sprouts, cabbage, cauliflower, cottonseed, cucumbers, eggplant, peppers, potatoes, summer squash and tomatoes.

38. PRIMARY NAME: Ethyl benzene (Ethylbenzene)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 4
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 45 Fed. Reg. 79334 (1980) (AWQC) -- 1400 μg/l
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79334 (1980) (AWQC) -- 1400 μg/l; (b) 45 Fed. Reg. 79334 (1980) (AWQC) -- 32,000 μg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

39. PRIMARY NAME: Fluoride
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: (a) 40 C.F.R. § 141.11(c) (NPDW -- MCL) -- 4000 μg/l; (b) 40 C.F.R. § 141.62(b) (NPDW -- MCL) -- 4000 μg/l; (c) 40 C.F.R. § 141.50(b) (NPDW -- MCLG) -- 4000 μg/l.
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: (a) 40 C.F.R. § 141.11(c) (NPDW -- MCL) -- 4000 μg/l; (b) 40 C.F.R. § 141.62(b) (NPDW -- MCL) -- 4000 μg/l; (c) 40 C.F.R. § 141.50(b) (NPDW -- MCLG) -- 4000 μg/l.
Biota RI Analyte: No
Potential Biota ARAR: No

40. PRIMARY NAME: Isodrin
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

41. PRIMARY NAME: Lead
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: 40 C.F.R. § 50.12 (NAAQS) -- 1.5 micrograms per cubic meter, maximum arithmetic mean averaged over a calendar quarter
Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 μg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 μg/l;
(c) 45 Fed. Reg. 79336 (1980) (AWQC) -- 50 μg/l (Human Health).
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 50 μg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 50 μg/l;
(c) 45 Fed. Reg. 79336 (1980) (AWQC) -- 50 μg/l (Human Health);
(d) 45 Fed. Reg. 79336 (1980) (AWQC) -- 24 hour limit to not exceed e (2.35 [In(hardness)] - 9.48) and concentration at any one time to not exceed e (1.22 [In(hardness)] - 0.47] (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

42. PRIMARY NAME: Magnesium
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

43. PRIMARY NAME: Magnesium hydroxide
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Magnesium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

44. PRIMARY NAME: Mercuric chloride
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Mercury)
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Mercury)
Potential Ground Water ARAR:
(a) (Mercury) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 2 µg/l;
(b) (Mercury) 45 Fed. Reg. 79336-79337 (1980) (AWQC) -- 144 ng/l (Human Health).

Soil RI Analyte: Yes (Mercury)
Soil EA Analyte: Yes (Mercury)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Mercury)
Potential Surface Water ARAR:
(a) (Mercury) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 2 µg/l;
(b) (Mercury) 45 Fed. Reg. 79336-79337 (1980) (AWQC) -- 144 ng/l (Human Health);
(c) (Mercury) 45 Fed. Reg. 79336 (1980) (AWQC) -- 0.00057 µg/l (as a 24-hour average and the concentration should not exceed 0.0017 µg/l at any one time) (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

45. PRIMARY NAME: Mercury
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR:
(a) 40 C.F.R. § 61.52(a) (NESHAP) -- emissions to atmosphere from mercury ore processing facilities not to exceed 2300 grams per 24-hour period;
(b) 40 C.F.R. § 61.52(b) (NESHAP) -- emissions to atmosphere from sludge incineration or drying plants not to exceed 3200 grams per 24-hour period.

Ground Water RI Analyte: Yes
Potential Ground Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 2 µg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 2 µg/l;
(c) 45 Fed. Reg. 79336-79337 (1980) (AWQC) -- 144 ng/l (Human Health).

Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR:
(a) 40 C.F.R. § 141.11(b) (NPDW -- MCL) -- 2 µg/l;
(b) 40 C.F.R. § 264.94(a)(2) (RCRA) -- 2 µg/l;
(c) 45 Fed. Reg. 79336-79337 (1980) (AWQC) -- 144 ng/l (Human Health);
(d) 45 Fed. Reg. 79336-79337 (1980) (AWQC) -- 24 hour average 0.00057 µg/l and concentration not to exceed 0.0017 µg/l at any one time (Aquatic Life).

Biota RI Analyte: No
Potential Biota ARAR: No

46. PRIMARY NAME: Nitrate
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 40 C.F.R. § 141.11(b) (NPDW--MCL) -- 10,000 μg/l
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: 40 C.F.R. § 141.11(b) (NPDW--MCL) -- 10,000 μg/l
Biota RI Analyte: No
Potential Biota ARAR: No

47. PRIMARY NAME: Nitrite
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

4 PRIMARY NAME: 1,4-Oxathiane (p-Thiozane)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

49. PRIMARY NAME: Sodium
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

50. PRIMARY NAME: Sodium bicarbonate, 1:1
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

51. PRIMARY NAME: Sodium bromate
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

52. PRIMARY NAME: Sodium carbonate, 2:1
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

53. PRIMARY NAME: Sodium methylate, alcohol mixture
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

54. PRIMARY NAME: Sodium nitrite
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

55. PRIMARY NAME: Sodium silicate
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Ye. (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

56. PRIMARY NAME: Sodium sulfite, 2:1
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

57. PRIMARY NAME: Sodium sulfonate
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

58. PRIMARY NAME: Sodium thiosulfate (Hypo)
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Sodium)
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

59. PRIMARY NAME: Sulfate
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

60. PRIMARY NAME: Sulfonic acid
CERCLA Hazardous Substance: No
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

61. PRIMARY NAME: p,p'-TDE
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: 45 Fed. Reg. 79331 (1980) (AWQC) -- 0.6 μg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

62. PRIMARY NAME: Tetrachlorobenzene (1,2,4,5-Tetrachlorobenzene)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: 45 Fed. Reg. 79327 (1980) (AWQC) -- 38 μg/l (Human Health)
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79327 (1980) (AWQC) -- 38 ug/l (Human Health);
(b) 45 Fed. Reg. 79327 (1980) (AWQC) -- 250 ug/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

63. PRIMARY NAME: 1,1,2,2-Tetrachloroethane
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: No
Potential Air ARAR: No
Ground Water RI Analyte: No
Potential Ground Water ARAR: No
Soil RI Analyte: No
Soil EA Analyte: No
Potential Soil ARAR: No
Surface Water RI Analyte: No
Potential Surface Water ARAR: No
Biota RI Analyte: No
Potential Biota ARAR: No

64. PRIMARY NAME: 1,1,2,2-Tetrachloroethylene (Perchloroethylene, PCE)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 45 Fed. Reg. 79341 (1980) (AWQC) -- 8 µg/l (10^{-5}), 0.8 µg/l (10^{-6}), 0.08 µg/l (10^{-7}) (Human Health)
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79341 (1980) (AWQC) -- 8 µg/l (10^{-5}), 0.8 µg/l (10^{-6}), 0.08 µg/l (10^{-7}) (Human Health); (b) 45 Fed. Reg. 79341 (1980) (AWQC) - 840 µg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

65. PRIMARY NAME: Toluene
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR: 45 Fed. Reg. 79340 (1980) (AWQC) -- 14,300 µg/l (Human Health)
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79340 (1980) (AWQC) -- 14,300 µg/l (Human Health); (b) 45 Fed. Reg. 79340 (1980) (AWQC) -- 17,500 µg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

66. PRIMARY NAME: 1,1,1-Trichloroethane
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 3
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: (a) 40 C.F.R. § 141.50 (NPDW -- MCLG) -- 200 µg/l;
(b) 40 C.F.R. § 141.61(a); 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 200 µg/l.
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 40 C.F.R. § 141.50 (NPDW -- MCLG) -- 200 µg/l;
(b) 40 C.F.R. § 141.61(a); 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 200 µg/l.
Biota RI Analyte: No
Potential Biota ARAR: No

67. PRIMARY NAME: Trichloroethylene (Trichloroethene, TCE)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 1
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: (a) 40 C.F.R. § 141.61(a); 52 Fed. Reg. 25716 (1987) (effective Jan. 9, 1989) (NPDW -- MCL) -- 5 µg/l;
(b) 45 Fed. Reg. 79341 (1980) (AWQC) -- 27 µg/l (10^{-5}), 2.7 µg/l (10^{-6}), 0.27 µg/l (10^{-7}) (Human Health).
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: (a) 45 Fed. Reg. 79341 (1980) (AWQC) -- 27 µg/l (10^{-5}), 2.7 µg/l (10^{-6}), 0.27 µg/l (10^{-7}) (Human Health);
(b) 45 Fed. Reg. 79341 (1980) (AWQC) -- 45,000 µg/l (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

68. PRIMARY NAME: Xylene (includes m,o, p-Xylene)
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 3
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: 40 C.F.R. § 180.1025(c) (TPCRAC) -- Xylene is not to be applied to irrigation conveyances where there is any likelihood that the irrigation water will be used as a source of potable water, or that return flows to rivers and streams could contain residues of Xylene in excess of 10 parts per million.
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: 40 C.F.R. § 180.1025(c) (TPCRAC) -- Xylene is not to be applied to irrigation conveyances where there is any likelihood that the irrigation water will be used as a source of potable water, or that return flows to rivers and streams could contain residues of Xylene in excess of 10 parts per million.
Biota RI Analyte: No
Potential Biota ARAR: No

69. PRIMARY NAME: Zinc
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: Priority Group 2
Air Analyte: Yes
Potential Air ARAR: No
Ground Water RI Analyte: Yes
Potential Ground Water ARAR: No
Soil RI Analyte: Yes
Soil EA Analyte: Yes
Potential Soil ARAR: No
Surface Water RI Analyte: Yes
Potential Surface Water ARAR: 45 Fed. Reg. 79341 (1980) (AWQC) -- 24 hour average is 47 $\mu g/l$ and should not exceed e (0.83[In(hardness)] + 1.95) at any one time (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No

70. PRIMARY NAME: Zinc oxide
CERCLA Hazardous Substance: Yes
Ranking on ATSDR Priority List: No
Air Analyte: Yes (Zinc)
Potential Air ARAR: No
Ground Water RI Analyte: Yes (Zinc)
Potential Ground Water ARAR: No
Soil RI Analyte: Yes (Zinc)
Soil EA Analyte: Yes (Zinc)
Potential Soil ARAR: No
Surface Water RI Analyte: Yes (Zinc)
Potential Surface Water ARAR: 45 Fed. Reg. 79341 (1980) (AWQC-Zinc) -- 24 hour average is 47 $\mu g/l$ and should not exceed e (0.83 [In(hardness)] + 1.95) at any one time (Aquatic Life).
Biota RI Analyte: No
Potential Biota ARAR: No